RFB NO. 317049

CONSTRUCTION DOCUMENTS

PROJECT MANUAL

DANE COUNTY DEPARTMENT OF PUBLIC WORKS,
HIGHWAY AND TRANSPORTATION

PUBLIC WORKS SOLID WASTE DIVISION
1919 ALLIANT ENERGY CENTER WAY
MADISON, WISCONSIN 53713

REQUEST FOR BIDS NO. 317049
BIOGAS FACILITY CONSTRUCTION
DANE COUNTY LANDFILL SITE NO. 2
7102 U.S. HIGHWAY 12 & 18
MADISON, WISCONSIN

Due Date / Time: **TUESDAY, MAY 1, 2018 / 2:00 PM**

Location: **PUBLIC WORKS OFFICE**

Performance / Payment Bond: **100% OF CONTRACT AMOUNT**

Bid Deposit: **5% OF BID AMOUNT**

FOR INFORMATION ON THIS REQUEST FOR BIDS, PLEASE CONTACT:

JOHN WELCH, SOLID WASTE MANAGER
TELEPHONE NO.: 608/516 -4154
FAX NO.: 608/267-1533
E-MAIL: WELCH@COUNTYOFDANE.COM

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Drawings for RFB are a separate document entitled "Dane County No. 2 (Rodefeld) Landfill Bioas Facility Construction", March 2018, prepared by Cornerstone Environmental Group, LLC, a Tetra Tech Company.

Plot drawings on 22" X 34" (ANSI D) paper for correct scale.

LEGAL NOTICE

INVITATION TO BID

Dane County Public Works, Highway & Transportation Dept., 1919 Alliant Energy Center Way, Madison, WI 53713, will receive sealed Bids until:

2:00 P.M., TUESDAY, APRIL 24, 2018

REQUEST FOR BIDS NO. 317049

BIOGAS FACILITY CONSTRUCTION

DANE COUNTY LANDFILL SITE NO. 2

7102 U.S. HIGHWAY 12 & 18

MADISON, WISCONSIN

Dane County is inviting Bids for construction services to develop approximately 5 acres into a biogas processing facility located on Dane County property. Work will include all civil site work, building construction, and all associated equipment procurement and installation. Only firms with capabilities, experience & expertise with similar projects should obtain this Request for Bids document & submit Bids.

Request for Bids document may be obtained after **2:00 p.m. on Tuesday, March 27, 2018** by downloading it from bids-pwht.countyofdane.com. Please call John Welch, Solid Waste Manager, at 608/516-4154, or our office at 608/266-4018, for any questions or additional information.

All Bidders must be a registered vendor with Dane County & pay an annual registration fee & must be pre-qualified as a Best Value Contractor before award of Contract. Complete Vendor Registration Form at danepurchasing.com/Account/Login? or obtain one by calling 608/266-4131. Complete Pre-qualification Application for Contractors at countyofdane.com/pwht/BVC_Application.aspx or obtain one by calling 608/266-4029.

A pre-bid site tour will be held Thursday, April 12, 2018 at 10:00 a.m. at Dane County Landfill Site No. 2, starting at the Scale House. Bidders are encouraged to attend this optional tour.

PUBLISH: **TUESDAY, MARCH 27 & APRIL 3, 2018 - WISCONSIN STATE JOURNAL**
TUESDAY, MARCH 27 & APRIL 3, 2018 - THE DAILY REPORTER

DANE COUNTY DEPARTMENT of PUBLIC WORKS, HIGHWAY and TRANSPORTATION

County Executive
Joseph T. Parisi

1919 Alliant Energy Center Way ◆ Madison, Wisconsin 53713
Phone: (608) 266-4018 ◆ FAX: (608) 267-1533

Commissioner / Director
Gerald J. Mandli

BEST VALUE CONTRACTING APPLICATION

CONTRACTORS / LICENSURE APPLICANTS

The Dane County Department of Public Works requires all contractors to be pre-qualified as a best value contractor with the County prior to being awarded a contract. In addition, the County pre-qualifies potential contractors and sub-contractors who wish to work on County contracts. Subcontractors must become pre-qualified ten (10) days prior to commencing work under any Dane County Public Works Contract. Potential subcontractors are urged to become pre-qualified as early as possible. This document shall be completed, properly executed, along with the necessary attachments and additional information that the County requires for the protection and welfare of the public in the performance of a County contract.

Contractors or subcontractors of any tier who attain pre-qualification status will retain that status for a period of two (2) years from the date of qualification. Contractors shall notify the Dane County Department of Public Works, Highway & Transportation within fifteen (15) days of any changes to its business or operations that are relevant to the pre-qualification application. Failure to do so could result in suspension, revocation of the contractor's pre-qualification, debarment from County contracts for up to three (3) years and / or other sanctions available under the law.

No contracts will be awarded for construction work performed on Dane County projects unless the contractor is currently approved as a Wisconsin Trade Trainer or has applied for approval as an Apprenticeship Trade Trainer to the Wisconsin Department of Workforce Development and agrees to an acceptable apprenticeship program. If you are not currently approved as a Wisconsin Trade Trainer, or have not applied for approval as an Apprenticeship Trade Trainer, please contact the Department of Workforce Development - Bureau of Apprenticeship Standards at 608/266-3133 or visit their web site at: dwd.wisconsin.gov/apprenticeship/.

EXEMPTIONS

- Contractors who employ less than five (5) apprenticeable trade workers are not required to pre-qualify.
- Contractors performing work that does not apply to an apprenticeable trade, as outlined in Appendix A.
- The contractor / subcontractor provides sufficient documentation to demonstrate one or more of the following:
  - apprentices are not available in a specific geographic area;
  - the applicable apprenticeship program is unsuitable or unavailable; or
  - there is a documented depression of the local construction market which prevents compliance.

SEC.	PROOF OF RESPONSIBILITY	CHECK IF APPLICABLE
1	Does your firm possesses all technical qualifications and resources, including equipment, personnel and financial resources, necessary to perform the work required for any project or obtain the same through the use of responsible, pre-qualified subcontractors?	Yes: ☐ No: ☐
2	Will your firm possess all valid, effective licenses, registrations or certificates required by federal, state, county, or local law, which are necessary for the type of work to be performed including, but not limited to, those for any type of trade work or specialty work?	Yes: ☐ No: ☐
3	Will your firm meet all bonding requirements as required by applicable law or contract specifications?	Yes: ☐ No: ☐
4	Will your firm meet all insurance requirements as required by applicable law or specifications, including general liability insurance, workers compensation insurance and unemployment insurance requirements?	Yes: ☐ No: ☐
5	Will your firm maintain a substance abuse policy for employees hired for public works contracts that comply with Wis. Stats. Sec. 103.503?	Yes: ☐ No: ☐
6	Does your firm acknowledge that it must pay all craft employees on public works projects the wage rates and benefits required under Section 66.0903 of the Wisconsin Statutes?	Yes: ☐ No: ☐
7	Will your firm fully abide by the equal opportunity and affirmative action requirements of all applicable laws, including County ordinances?	Yes: ☐ No: ☐
8	In the past three (3) years, has your firm had control or has another corporation, partnership or other business entity operating in the construction industry controlled it? If so, please attach a statement explaining the nature of the firm relationship?	Yes: ☐ No: ☐ If Yes, attach details.
9	In the past three (3) years, has your firm had any type of business, contracting or trade license, certification or registration revoked or suspended?	Yes: ☐ No: ☐ If Yes, attach details.
10	In the past three (3) years, has your firm been debarred by any federal, state or local government agency?	Yes: ☐ No: ☐ If Yes, attach details.
11	In the past three (3) years, has your firm defaulted or failed to complete any contract?	Yes: ☐ No: ☐ If Yes, attach details.
12	In the past three (3) years, has your firm committed a willful violation of federal, state or local government safety laws as determined by a final decision of a court or government agency authority.	Yes: ☐ No: ☐ If Yes, attach details.
13	In the past three (3) years, has your firm been in violation of any law relating to your contracting business where the penalty for such violation resulted in the imposition of a penalty greater than $10,000?	Yes: ☐ No: ☐ If Yes, attach details.
14	Is your firm Executive Order 108 precertified with the State of Wisconsin?	Yes: No: ☐
15	Is your firm an active Wisconsin Trade Trainer as determined by the Wisconsin Bureau of Apprenticeship Standards?	Yes: ☐ No: ☐
16	Is your firm exempt from being pre-qualified with Dane County?	Yes: ☐ No: ☐ If Yes, attach reason for exemption.
17	Does your firm acknowledge that in doing work under any County Public Works Contract, it will be required to use as subcontractors only those contractors that are also pre-qualified with the County or become so ten days prior to commencing work?	Yes: ☐ No: ☐
18	Contractor has been in business less than one year?	Yes: ☐ No: ☐
19	Is your firm a first time Contractor requesting a one time exemption, but, intend to comply on all future contracts and are taking steps typical of a "good faith" effort?	Yes: ☐ No: ☐
20	Not applicable. My firm does not intend to work on Best Value Contracts. Note: Best Value Contracting is required to bid on most Public Works Contracts (if unclear, please call Jan Neitzel Knox 608-266-4029).	Yes: ☐ No: ☐

SIGNATURE SECTION

Your firm's Officer, or the individual who would sign a bid and / or contract documents must sign this document.

I do hereby certify that all statements herein contained are true and correct to the best of my knowledge:

Signature ______________________ Date ______________

Printed or Typed Name and Title ______________________

NAME AND ADDRESS OF CONTRACTOR	
Name of Firm:	
Address:	
City, State, Zip:	
Telephone Number:	
Fax Number:	
E-mail Address:	

REMEMBER!

Return all to forms and attachments, or questions to:

JAN NEITZEL KNOX
EMAIL: NEITZEL-KNOX@COUNTYOFDANE.COM
OFFICE: (608)266-4029, FAX: (608)267-1533

DANE COUNTY DEPARTMENT OF PUBLIC WORKS,
HGHWAY & TRANSPORTATION
1919 ALLIANT ENERGY CENTER WAY
MADISON, WI 53713

APPENDIX A

APPRENTICEABLE TRADES

Bricklayer
Carpenter
Cement Mason (Concrete Finisher)
Cement Mason (Heavy Highway)
Construction Craft Laborer
Data Communications Installer
Electrician
Elevator Mechanic / Technician
Environmental Systems Technician / HVAC Service Technician / HVAC Install & Service
Glazier
Heavy Equipment Operator / Operating Engineer
Insulation Worker (Heat & Frost)
Iron Worker (Assembler, Metal Buildings)
Painter / Decorator
Plasterer
Plumber
Roofer / Waterproofer
Sheet Metal Worker
Sprinkler Fitter
Steamfitter (Service & Refrigeration)
Taper & Finisher
Telecommunications (Voice, Data & Video) Installer / Technician
Tile Setter

INSTRUCTIONS TO BIDDERS

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1. GENERAL

A. Before submitting Bid, bidder shall thoroughly examine all Construction Documents. Successful Bidder shall be required to provide all the Work that is shown on Drawings, set forth in Specifications, or reasonably implied as necessary to complete Contract for this project.

B. Bidder shall visit site to become acquainted with adjacent areas, means of approach to site, conditions of actual site and facilities for delivering, storing, placing, and handling of materials and equipment.

C. Pre-bid meeting is scheduled on Thursday, April 12, 2018 at 10:00 a.m. at Dane County Landfill Site No. 2 starting at the Scale House. Attendance by all bidders is optional, however bidders and subcontractors are strongly encouraged to attend.

D. Visits at other times can also be arranged. Coordinate site access activities with Solid Waste Manager, John Welch, 608/516-4154.

E. Failure to visit site or failure to examine any and all Construction Documents will in no way relieve successful Bidder from necessity of furnishing any necessary materials or equipment, or performing any work, that may be required to complete the Work in accordance with Drawings and Specifications. Neglect of above requirements will not be accepted as reason for delay in the Work or additional compensation.

2. DRAWINGS AND SPECIFICATIONS

A. Drawings and Specifications that form part of this Contract, as stated in Article 1 of General Conditions of Contact, are enumerated in Document Index of these Construction Documents.

B. Complete sets of Drawings and Specifications for all trades will be available to all Bidders, irrespective of category of work to be bid on, in order that all Bidders may be familiar with work of other trades as they affect their bid.

3. INTERPRETATION

A. No verbal explanation or instructions will be given in regard to meaning of Drawings or Specifications before Bid Due Date. Bidders shall bring inadequacies, omissions or conflicts to Owner or Architect / Engineer's attention at least ten (10) calendar days before Bid Due Date. Prompt clarification will be available to all bidders by Addendum.

B. Failure to so request clarification or interpretation of Drawings and Specifications will not relieve successful Bidder of responsibility. Signing of Contract will be considered as implicitly denoting that Contractor has thorough understanding of scope of the Work and comprehension of Construction Documents.

C. Owner or Architect / Engineer will not be responsible for verbal instructions.

4. QUALIFICATIONS OF BIDDER (CONTRACTOR AND SUBCONTRACTOR)

A. Before award of Contract can be approved, Owner shall be satisfied that Bidder involved meets following requirements:

1. Has completed at least one (1) project of at least fifty percent (50%) of size or value of Division of work being bid and type of work completed is similar to that being bid. If greater magnitude of experience is deemed necessary, other than size or value of work, such requirements will be described in appropriate section of Specifications.

2. Maintains permanent place of business.

3. Can be bonded for terms of proposed Contract.

4. Has record of satisfactorily completing similar past projects. Contractor shall submit a list of three (3) most recent, similar projects of at least 50% value of this project, with architect or engineer's and owner's names, addresses and telephone numbers for each project. Submit to Public Works Project Manager with Bid. Criteria which will be considered in determining satisfactory completion of projects by bidder will include:

   a. Completed contracts in accordance with drawings and specifications.
   b. Diligently pursued execution of work and completed contracts according to established time schedule unless Owner grants extensions.
   c. Fulfilled guarantee requirements of construction documents.
   d. Is not presently on ineligible list maintained by County's Department of Administration for noncompliance with equal employment opportunities and affirmative action requirements.
   e. Authorized to conduct business in Wisconsin. By submitting Bid, bidder warrants that it has: complied with all necessary requirements to do business in State of Wisconsin; that persons executing contract on its behalf are authorized to do so; and, if corporation, that name and address of bidder's registered agent are as set forth in Contract. Bidder shall notify Owner immediately, in writing, of any change in its registered agent, their address, and bidder's legal status. For partnership, term "registered agent" shall mean general partner.

B. County's Public Works Project Manager will make such investigations as are deemed necessary to determine ability of bidder to perform the Work, and bidder shall furnish to County's Public Works Project Manager or designee all such information and data for this purpose as County's Public Works Project Manager may request. Owner reserves right to reject Bid if evidence submitted by, or investigation of, bidder fails to satisfy Owner that bidder is responsible and qualified to carry out obligations of Contract and to complete the Work contemplated therein.

5. BID GUARANTEE

A. Bank certified check, cashier's check or Bid Bond, payable to County in amount not less than five percent (5%) of maximum bid, shall accompany each Bid as guarantee that if Bid is accepted, Bidder will execute and return proposed Contract and Performance and Payment Bonds within ten (10) business days after being notified of acceptance of Bid. Company issuing bonds must be licensed to do business in Wisconsin.

B. Any bid, which is not accompanied by bid guarantee, will be considered "No Bid" and will not be read at Bid Due Date.

C. If successful Bidder so delivers Contract, Certificate of Insurance, and Performance and Payment Bonds, check will be returned to Bidder. In case Bidder fails to deliver such Contract, insurance, and bond, amount of bid guarantee will be forfeited to County as liquidated damages.

D. All checks tendered as bid guarantee, except those of three (3) lowest qualified, responsible bidders, will be returned to their makers within three (3) business days after Bid Due Date. All such retained checks will be returned immediately upon signing of Contract and Performance and Payment Bonds by successful Bidder.

6. WITHDRAWAL OF BIDS

A. Bids may be withdrawn by written request received from bidder or authorized representative thereof prior to time fixed for Bid Due Date, without prejudice to right of bidder to file new Bid. Withdrawn Bids will be returned unopened. Negligence on part of bidder in preparing their Bid confers no right for withdrawal of Bid after it has been opened.

B. No Bid may be withdrawn for period of sixty (60) calendar days after Bid Due Date.

C. If Bid contains error, omission or mistake, bidder may limit liability to amount of bidder's guarantee by giving written Notice of Intent not to execute Contract to Owner within seventy-two (72) hours of Bid Due Date.

7. CONTRACT FORM

A. Sample copy of contract that successful Bidder will be required to enter into is included in these Construction Documents and bidders are required to familiarize themselves with all conditions contained therein.

8. CONTRACT INTERESTS BY COUNTY PUBLIC OFFICIALS

A. In accordance with Wisconsin Statute 946.13, county official may not bid for or enter into any contract involving receipts or disbursements of more than $15,000.00 in a year, in which they have private pecuniary interest, direct or indirect if at same time they are authorized to take official action with respect to making of this Contract. Any contract entered into in violation of this Statute is void and County incurs no liability thereon. This subsection does not affect application and enforcement of Wisconsin Statute 946.13 by state prosecutors in criminal courts of this state.

9. EMERGING SMALL BUSINESS PROVISIONS

A. **Emerging Small Business Definition.** For purposes of this provision, ESB is defined as:

1. Independent business concern that has been in business minimum of one year;
2. Business located in State of Wisconsin;
3. Business comprised of less than twenty-five (25) employees;
4. Business must not have gross sales in excess of three million dollars ($3,000,000.00) over past three years; and
5. Business does not have history of failing to complete projects.

B. **Emerging Small Business (ESB) Involvement.** Bidder shall make good faith effort to award minimum of ten percent (10%) of the Work to ESBs. Bidder shall submit report to Dane County Contract Compliance Officer within ten (10) business days of Bid Due Date demonstrating such efforts. Good faith efforts means significant contact with ESBs for purposes of soliciting bids from them. Failure to make or demonstrate good faith efforts will be grounds for disqualification.

C. **Emerging Small Business Report.** Emerging Small Business Enterprise Report is to be submitted by Bidder in separate envelope marked “Emerging Small Business Report”. This report is due by 2:00 p.m. following specified ten (10) business days after Bid Due Date. Bidder who fails to submit Emerging Small Business Report shall be deemed not responsive.

D. **ESB Goal.** Goal of this project is ten percent (10%) ESB participation. ESB utilizations are shown as percentage of total Bid. If Bidder meets or exceeds specified goal, Bidder is only required to submit Form A - Certification, and Form B - Involvement. Goal shall be met if Bidder qualifies as ESB.

E. **Report Contents.** Following award of Contract, Bidder shall submit copies of executed contracts for all Emerging Small Businesses. Emerging Small Business Report shall consist of these:

1. Form A - Certification;
2. Form B - Involvement;
3. Form C - Contacts;
4. Form D - Certification Statement (if appropriate); and
5. Supportive documentation (i.e., copies of correspondence, telephone logs, copies of advertisements).

F. ESB Listing. Bidders may solicit bids from this ESB listing: pdf.countyofdane.com/commissions/2013-2015_Targeted_Business_Directory.pdf.

G. **ESB Certification.** All contractors, subcontractors and suppliers seeking ESB certification must complete and submit Emerging Small Business Report to Dane County Contract Compliance Program.

H. **Certification Statement.** If ESB firm has not been certified by County as ESB prior to submittal of this Bid, ESB Report cannot be used to fulfill ESB goal for this project unless firm provides "Form D - Certification Statement". Certification statement must be completed and signed by ESB firm.

I. **Questions.** Questions concerning Emerging Small Business provisions shall be directed to:

Dane County Contract Compliance Officer
City-County Building, Room 421
210 Martin Luther King, Jr. Blvd.
Madison, WI 53703
608/266-5623

J. **Substituting ESBs.** In event of any significant changes in subcontract arrangements or if need arises to substitute ESBs, Bidder shall report such proposed changes to Contract Compliance Officer to making any official changes and request authorization to substitute ESB firm. Bidder further agrees to make every possible effort to replace ESB firm with another qualified ESB firm.

K. **Good Faith Efforts.** Good faith efforts can be demonstrated by meeting all of these obligations:

1. Selecting portions of the Work to be performed by ESBs in order to increase likelihood of meeting ESB goal including, where appropriate, breaking down Contract into smaller units to facilitate ESB participation.

2. Advertising in general circulation, trade associations and women / minority focus media concerning subcontracting opportunities.

3. Providing written notices to reasonable number of specific ESBs that their interest in Contract was being solicited in sufficient time to allow ESBs to participate effectively.

4. Following up on initial solicitations of interest by contacting ESBs within five (5) business days prior to Bid Due Date to determine with certainty whether ESB were interested, to allow ESBs to prepare bids.

5. Providing interested ESB with adequate information about Drawings, Specifications and requirements of Contract.

6. Using services of available minority, women and small business organizations and other organizations that provide assistance in recruitment of MBEs / WBEs / ESBs.

7. Negotiating in good faith with interested ESBs, not rejecting ESBs as unqualified without sound reason based on thorough investigation of their capabilities.

8. Submitting required project reports and accompanying documents to County's Contract Compliance Officer within twenty-four (24) hours after Bid Due Date.

L. **Appeals Disqualification of Bid.** Bidder who is disqualified may appeal to Public Works & Transportation Committee and Equal Opportunity Commission.

10. METHOD OF AWARD - RESERVATIONS

A. Following will be basis of award of Contract, providing cost does not exceed amount of funds then estimated by County as available to finance Contract(s):

1. Lowest dollar amount submitted by qualified responsible bidder on Base Bid for all work comprising project, combined with such additive Owner accepted alternates.

2. Owner reserves right to reject all bids or any bid, to waive any informality in any bid, and to accept any bid that will best serve interests of County.

3. Unit Prices and Informational Bids will not be considered in establishing low bidder.

11. SECURITY FOR PERFORMANCE AND PAYMENTS

A. Simultaneous with delivery of signed Contract, Bidder shall be required to furnish Performance and Payment Bonds as specified in Article 29 of General Conditions of Contract, "Contract Security". Surety Company shall be licensed to do business in Wisconsin. Performance and Payment Bonds must be dated same date or subsequent to date of Contract. Performance and Payment Bonds must emulate information in Sample Performance and Payment Bonds in Construction Documents.

B. Provide certified copy of power of attorney from Surety Company showing that agent who signs Bond has power of attorney to sign for Surety Company. Secretary or Assistant Secretary of company must sign this certification, not attorney-in-fact. Certification must bear same or later date as Bond. Power of Attorney must emulate model power of attorney information detailed in Sample Performance and Payment Bonds.

C. If Bidder is partnership or joint venture, State certified list, providing names of individuals constituting partnership or joint venture must be furnished. Contract itself may be signed by one partner of partnership, or one partner of each firm comprising joint venture, but Performance and Payment Bonds must be signed by all partners.

D. If Bidder is corporation, it is necessary that current certified copy of resolution or other official act of directors of corporation be submitted showing that person who signs Contract is authorized to sign contracts for corporation. It is also necessary that corporate seal be affixed to resolution, contract, and performance and payment bonds. If your corporation has no seal, it is required that above documents include statement or notation to effect that corporation has no seal.

12. TAXES

A. Wisconsin Statute 77.54 (9m) allows building materials that become part of local unit government facilities to be exempt from sales & use tax. Vendors & materials suppliers may not charge Bidders sales & use tax on these purchases. This does not include highways, streets or roads. Any other Sales, Consumer, Use & other similar taxes or fees required by law shall be included in Bid.

B. In accordance with Wisconsin Statute 71.80(16)(a),successful nonresident bidder, whether incorporated or not, and not otherwise regularly engaged in business in this state, shall file surety bond with State of Wisconsin Department of Revenue payable to Department of Revenue, to guarantee payment of income taxes, required unemployment compensation contributions, sales and use taxes and income taxes withheld from wages of employees, together with any penalties and interest thereon. Amount of bond shall be three percent (3%) of Contract or subcontract price on all contracts of $50,000 or more.

13. SUBMISSION OF BIDS

A. All Bids shall be submitted on standard Bid Form bound herein and only Bids that are made on this Bid Form will be considered. Entire Bid Form and other supporting documents, if any, shall be removed or copied from Construction Documents, filled out, and submitted in manner specified hereinafter. Submit completed Bid Bond with Bid as well.

B. No bids for any subdivision or any sub-classification of this Work, except as indicated, will be accepted. Any conditional Bid, amendment to Bid Form or appended item thereto, or inclusion of any correspondence, written or printed matter, or details of any nature other than that specifically called for, which would alter any essential provision of Construction Documents, or require consideration of unsolicited material or data in determining award of Contract, will disqualify Bid. Telecommunication alterations to Bid will not be accepted.

C. Bidders must submit single Bid for all the Work.

D. Bid amounts shall be inserted in words and in figures in spaces provided on Bid Form; in case of conflict, written word amounts will govern.

E. Addenda issued after Bid Letting shall become part of Construction Documents. Bidders shall acknowledge receipt of such addenda in appropriate space provided on Bid Form. Bid may be rejected if receipt of any particular addendum applicable to award of Contract has not been acknowledged on Bid Form.

F. Bids shall be signed, placed in envelope, sealed and delivered before due time to place designated in Invitation to Bid, and identified with project name, bid number, location, category of work being bid upon, Bid Due Date, name and address of bidder.

G. Bidder shall be responsible for sealed Bid being delivered to place designated for Bid Due Date on or before date and time specified. Bids received after time of closing will be rejected and returned to bidder unopened.

H. Bid will be considered invalid and will be rejected if bidder has not signed it.

I. Faxed or emailed Bids will not be accepted.

J. Bidder's organization shall submit completed with Bid, Fair Labor Practices Certification form, included in these Construction Documents.

14. SUBCONTRACTOR LISTING

A. Bidders shall be required to submit list of major subcontractors for General Construction, Plumbing, HVAC, and Electrical work proposed for this project to include committed prices for each subcontractor. List shall be placed in separate sealed envelope that must be clearly identified as "Major Subcontractor List", for named project and name of Bidder submitting it. County must receive envelope no later than date by which successful Bidder is required to submit his or her signed Contract, as established in Construction Documents.

15. ALTERNATE BIDS

A. Bidder shall carefully read requests for Alternate Bids, and thoroughly examine Drawings and Specifications to determine extent various changes and conditions will affect Bid.

B. Space is provided in Bid Form for requested Alternate Bids. Failure to submit bid for any requested Alternate Bids may result in rejection of entire Bid.

C. Bidder shall state amount to be added / subtracted to Base Bid for providing alternates, including all incidentals, omissions, additions, and adjustments as may be necessary or required by such changes. If there is no difference in price, Bidder shall state, "No Change".

D. Descriptions of requested Alternate Bids are as set forth in Construction Documents.

16. INFORMATIONAL BIDS

A. Not Applicable.

17. UNIT PRICES

A. Not Applicable.

18. COMMENCEMENT AND COMPLETION

A. Successful Bidder shall commence work when schedule and weather permit, but no later than stated in Bid Form. Contractor shall pursue the Work regularly and continuously at reasonable rate to insure completion of the Work within time stated in Bid.

B. Should it be found impossible to complete the Work on or before time specified for completion, written request may be submitted for extension of time setting forth reasons believed to justify granting of such request. Refer to Article 20 of General Conditions of Contract, titled "Time for Completion".

19. WORK BY OWNER

A. See Section 01 11 00 titled "Summary of Work" for Work by Owner.

20. SPECIAL HAZARDS COVERAGE

A. Not Applicable.

FORM A

DANE COUNTY
EMERGING SMALL BUSINESS REPORT - CERTIFICATION

In accordance with General Conditions of Contract, submit this Emerging Small Business Report within ten (10) days after Bid Due Date.

PROJECT NAME: ____

____

BID NO.: ___________________________ BID DUE DATE: ________________________

BIDDER INFORMATION

COMPANY NAME: ____

ADDRESS: ____

____

TELEPHONE NO.: ____

CONTACT PERSON: ____

EMAIL ADDRESS: ____

FORM B

DANE COUNTY
EMERGING SMALL BUSINESS REPORT - INVOLVEMENT

(Copy this Form as necessary to provide complete information)

COMPANY NAME: ____

PROJECT NAME: ____

BID NO.: ____________________ BID DUE DATE: ____________________

ESB NAME: ____

CONTACT PERSON: ____

ADDRESS: ____

____

PHONE NO & EMAIL.: ____

____

Indicate percentage of financial commitment to this ESB: ______% Amount: $______________

ESB NAME: ____

CONTACT PERSON: ____

ADDRESS: ____

____

PHONE NO & EMAIL.: ____

____

Indicate percentage of financial commitment to this ESB: ______% Amount: $______________

FORM C

Page ___ of ___

DANE COUNTY

(Copy this Form as necessary to provide complete information)

EMERGING SMALL BUSINESS REPORT - CONTACTS

COMPANY NAME: ____

PROJECT NAME: ____

BID NO.: ____________________ BID DUE DATE: ____________________

	ESB FIRM NAME CONTACTED	DATE	PERSON CONTACTED	DID ESB BID?	ACC-EPT BID?	REASON FOR REJECTION
1)						
2)						
3)						
4)						
5)						
6)						
7)						
8)						

FORM D

DANE COUNTY
EMERGING SMALL BUSINESS REPORT - CERTIFICATION STATEMENT

I, ____ , __________________________________ of
Name Title

____ certify to best of my knowledge and
Company

belief that this business meets Emerging Small Business definition as indicated in Article 9 and that information contained in this Emerging Small Business Report is true and correct.

____ __________________________
Bidder's Signature Date

BID FORM – REVISED 4/18/2018

BID FORM

BID NO. 317049
PROJECT: BIOGAS FACILITY CONSTRUCTION
DANE COUNTY LANDFILL SITE NO. 2

TO: DANE COUNTY DEPARTMENT OF PUBLIC WORKS, HIGHWAY & TRANSPORTATION PROJECT MANAGER
1919 ALLIANT ENERGY CENTER WAY
MADISON, WISCONSIN 53713

NOTE: WISCONSIN STATUTE 77.54 (9M) ALLOWS FOR NO SALES & USE TAX ON THE PURCHASE OF MATERIALS FOR COUNTY PUBLIC WORKS PROJECTS.

BASE BID - LUMP SUM:
Dane County is inviting Bids for construction services to develop approximately 5 acres into a biogas processing facility located on Dane County property. Work will include all civil site work, building construction, and all associated equipment procurement and installation. The undersigned, having examined the site where the Work is to be executed and having become familiar with local conditions affecting the cost of the Work and having carefully examined the Drawings and Specifications, all other Construction Documents and Addenda thereto prepared by Dane County Department of Public Works, Highway & Transportation hereby agrees to provide all labor, materials, equipment and services necessary for the complete and satisfactory execution of the entire Work, as specified in the Construction Documents, for the Base Bid stipulated sum of:

____ and __ /100 Dollars
Written Price

$____________________________
Numeric Price

For the following price(s) in accordance with the Contract Documents:

Item Number	Description	Unit	Quantity	Unit Price	Total Price
101	Mobilization and General Conditions	LS	1		
102	Site Preparation – General	LS	1		
103	Silt Fence	EA	2,638		
104	Silt Logs	EA	8		
105	Temporary Erosion Control Matting	SF	242,950		
106	Temporary Seeding	SF	242,950		
107	Excavation	CY	3,000		
108	Undercut and Backfill with General Fill	CY	2,000		

BID FORM – REVISED 4/18/2018

109	Undercut and Backfill with Special Fill	CY	2,000		
110	Structural Fill	CY	4,000		
111	RNG Area Finish Grading	LS	1		
112	Facility Concrete Pads	LS	1		
113	Fixed Bollards	EA	75		
114	Removable Bollards	EA	14		
115	Aggregate Base for Paved / Parking Areas	SF	57,080		
116	Asphalt Pavement Placement	SF	55,280		
117	Concrete Pavement Placement	SF	1,800		
118	Aggregate Pad	SF	3,150		
119	Blower Building and Office Building	LS	1		
120	Compression Building	LS	1		
121	Boiler Building	LS	1		
122	Metering Skid **Not in Contract**	NA	NA		
123	RNG Offload Facility Installation	LS	1		
124	Metering Skid Installation	Each	3		
125	Condensate Management	LS	1		
126	Blower and Flare Facility Installation	LS	1		
127	Below Ground Gas Piping	LS	1		
128	Above Ground Gas Piping	LS	1		
129	Above Ground Gas Piping Tie-Ins	LS	1		
130	GCCS Header Installation	LS	1		
131	Supply and Install Flow Meters, Gas Valves, and Pressure Regulators	LS	1		
132	Electrical Lines	LS	1		
133	Communication Lines	LS	1		
134	Mechanical	LS	1		
135	Surface Water Drainage Features	LS	1		
136	Fire Protection	LS	1		
137	Supply and Install Fence	LS	1		
138	Supply and Install Security Devices	LS	1		
139	Traffic Signage and Pavement Markings	LS	1		
140	Site Restoration	LS	1		
141	Stormwater Detention Basin	LS	1		
				Grand Total	

BID FORM – REVISED 4/18/2018

ALTERNATE BID 1 - LUMP SUM:
Add price for providing a 62'-8" by 48'-4" maintenance building per drawings and specifications.

____ and __ /100 Dollars
Written Price

$ ______________________________
Numeric Price (circle: Add or Deduct)

ALTERNATE BID 2 - LUMP SUM:
Add price for providing approximately 2,400 linear feet of transmission pipeline per drawings and specifications.

____ and __ /100 Dollars
Written Price

$ ______________________________
Numeric Price (circle: Add or Deduct)

Receipt of the following addenda and inclusion of their provisions in this Bid is hereby acknowledged:

Addendum No(s). ___________ through _____________

Dated ____

Dane County Public Works – Solid Waste Division must have this project completed by November 23, 2018. Assuming this Work can be started by June 18, 2018, what dates can you commence and complete this job?

Commencement Date: ______________________ Completion Date: ______________________
(final, not substantial)

I hereby certify that all statements herein are made on behalf of:

____
(Name of Corporation, Partnership or Person submitting Bid)

Select one of the following:
1. A corporation organized and existing under the laws of the State of ___________________, or

2. A partnership consisting of ____, or

3. A person conducting business as ____;

Of the City, Village, or Town of ______________________________ of the State of ________.

BID FORM – REVISED 4/18/2018

I have examined and carefully prepared this Bid from the associated Construction Documents and have checked the same in detail before submitting this Bid; that I have full authority to make such statements and submit this Bid in (its) (their) (my) behalf; and that the said statements are true and correct. In signing this Bid, we also certify that we have not, either directly or indirectly, entered into any agreement or participated in any collusion or otherwise taken any action in restraint of free competition; that no attempt has been made to induce any other person or firm to submit or not to submit a Bid; that this Bid has been independently arrived at without collusion with any other bidder, competitor, or potential competitor; that this Bid has not been knowingly disclosed prior to the Bids Due Date to another bidder or competitor; that the above statement is accurate under penalty of perjury.

The undersigned further agrees to honor the Base Bid and the Alternate Bid(s) for sixty (60) calendar days from date of Award of Contract.

SIGNATURE: ____

(Bid is invalid without signature)

Print Name: ______________________________ Date: ______________

Title: ____

Address: ____

Telephone No.: ____________________ Fax No.: ____________________

Email Address: ____

Contact Person: ____

BID FORM – REVISED 4/18/2018

THIS PAGE IS FOR BIDDERS' REFERENCE AND NEED NOT BE SUBMITTED WITH BID FORM.

BID CHECK LIST:
These items **must** be included with Bid:
☐ Bid Form ☐ Bid Bond ☐ Fair Labor Practices Certification
☐ Project Experience / Reference Summary

BIDDERS SHOULD BE AWARE OF THE FOLLOWING:

DANE COUNTY VENDOR REGISTRATION PROGRAM

Any person bidding on any County contract must be registered with the Dane County Purchasing Division & pay an annual registration fee. A contract will not be awarded to an unregistered vendor. Obtain a *Vendor Registration Form* by calling 608/266-4131 or complete a new form or renewal online at:
www.danepurchasing.com/registration

DANE COUNTY BEST VALUE CONTRACTING PRE-QUALIFICATION

Contractors must be pre-qualified as a Best Value Contractor with the Dane County Public Works Engineering Division before the award of contract. Obtain a *Best Value Contracting Application* by calling 608/266-4018 or complete one online at:
www.countyofdane.com/pwht/BVC_Application.aspx

EQUAL BENEFITS REQUIREMENT

By submitting a Bid, the contractor acknowledges that a condition of this contract is to provide equal benefits as required by Dane County Code of Ordinances Chapter 25.13. Contractor shall provide equal benefits as required by that Ordinance to all required employees during the term of the contract. Equal Benefits Compliance Payment Certification shall be submitted with final pay request. For more information:
www.danepurchasing.com/partner_benefit.aspx

FAIR LABOR PRACTICES CERTIFICATION

The undersigned, for and on behalf of the BIDDER, APPLICANT or PROPOSER named herein, certifies as follows:

A. That he or she is an officer or duly authorized agent of the above-referenced BIDDER, APPLICANT or PROPOSER, which has a submitted a bid, application or proposal for a contract or agreement with the county of Dane.

B. That BIDDER, APPLICANT or PROPOSER has (check one):

_______ not been found by the National Labor Relations Board ("NLRB") or the Wisconsin Employment Relations Commission ("WERC") to have violated any statute or regulation regarding labor standards or relations in the seven years prior to the signature date of this Certification.

_______ been found by the National Labor Relations Board ("NLRB") or the Wisconsin Employment Relations Commission ("WERC") to have violated any statute or regulation regarding labor standards or relations in the seven years prior to the signature date of this Certification.

______________________________ ______________

Officer or Authorized Agent Signature Date

____

Printed or Typed Name and Title

____

Printed or Typed Business Name

NOTE: You can find information regarding the violations described above at: www.nlrb.gov and werc.wi.gov.

For reference, Dane County Ordinance 25.11(28)(a) is as follows:
(28) BIDDER RESPONSIBILITY. (a) Any bid, application or proposal for any contract with the county, including public works contracts regulated under chapter 40, shall include a certification indicating whether the bidder has been found by the National Labor Relations Board (NLRB) or the Wisconsin Employment Relations Committee (WERC) to have violated any statute or regulation regarding labor standards or relations within the last seven years. The purchasing manager shall investigate any such finding and make a recommendation to the committee, which shall determine whether the conduct resulting in the finding affects the bidder's responsibility to perform the contract.

If you indicated that the NLRB or WERC have found you to have such a violation, you must include copies of any relevant information regarding such violation with your proposal, bid or application.

Include this completed Certification with your bid, application or proposal.

COUNTY OF DANE

PUBLIC WORKS CONSTRUCTION CONTRACT

Contract No. ____________________ Bid No. 317049

Authority: 2017 RES -_________

THIS CONTRACT, made and entered into as of the date by which authorized representatives of both parties have affixed their signatures, by and between the County of Dane (hereafter referred to as "COUNTY") and ________________________________ (hereafter, "CONTRACTOR"), and

W I T N E S S E T H :

WHEREAS, COUNTY, whose address is c/o Assistant Public Works Director, 1919 Alliant Energy Center Way, Madison, WI 53713, desires to have CONTRACTOR provide Biogas Facility Construction ("the Project"); and

WHEREAS, CONTRACTOR, whose address is ____ ____ is able and willing to construct the Project, in accordance with the Construction Documents;

NOW, THEREFORE, in consideration of the above premises and the mutual covenants of the parties hereinafter set forth, the receipt and sufficiency of which is acknowledged by each party for itself, COUNTY and CONTRACTOR do agree as follows:

1. CONTRACTOR agrees to construct, for the price of $_____________ the Project and at the CONTRACTOR'S own proper cost and expense to furnish all materials, supplies, machinery, equipment, tools, superintendence labor, insurance, and other accessories and services necessary to complete the Project in accordance with the conditions and prices stated in the Bid Form, General Conditions of Contract, the drawings which include all maps, plats, plans, and other drawings and printed or written explanatory matter thereof, and the specifications therefore as prepared by Cornerstone Environmental Group LLC (hereinafter referred to as "the Architect / Engineer"), and as enumerated in the Project Manual Table of Contents, all of which are made a part hereof and collectively evidence and constitute the Contract.

2. COUNTY agrees to pay the CONTRACTOR in current funds for the performance of the Contract subject to additions and deductions, as provided in the General Conditions of Contract, and to make payments on account thereof as provided in Article entitled, "Payments to Contractor" of the General Conditions of Contract.

3. Contract Times

Time of the Essence

A. All time limits for Substantial Completion and completion and readiness for final payment as stated in the Contract Documents are of the essence of the Contract.

Contract Times: Dates

B. The Work shall be substantially completed on or before the following date: November 16, 2018.

Substantially complete means the following Work shall be completed:

1. Any start-up or commissioning required for operation,
2. Final walk through completed,
3. Development of punch-list, and
4. Final planting, seeding and mulching.

C. Work shall be completed and ready for final payment on or before the following date: November 23, 2018.

Liquidated Damages

D. Contractor and Owner recognize that time is of the essence as stated above and that Owner will suffer financial and other losses if the Work is not completed within the times specified above, plus any extensions thereof allowed in accordance with the Contract. The parties also recognize the delays, expense, and difficulties involved in proving in a legal or arbitration proceeding the actual loss suffered by Owner if the Work is not completed on time. Accordingly, instead of requiring any such proof, Owner and Contractor agree that as liquidated damages for delay (but not as a penalty):

1. Substantial Completion: Contractor shall pay Owner $10,000 for each day that expires after the time (as duly adjusted pursuant to the Contract) specified above for Substantial Completion until the Work is substantially complete.
2. Completion of Remaining Work: After Substantial Completion, if Contractor shall neglect, refuse, or fail to complete the remaining Work within the Contract Time (as duly adjusted pursuant to the Contract) for completion and readiness for final payment, Contractor shall pay Owner $5,000 for each day that expires after such time until the Work is completed and ready for final payment.
3. Liquidated damages for failing to timely attain Substantial Completion and final completion are not additive and will not be imposed concurrently.
4. Liquidated damages for failing to timely attain Substantial Completion and Final Completion shall be capped at 10% of the total contract amount.
5. There shall be no delays or adjustment to the dates for weather delays for the first 5 days of weather delays. Following the first 5 days of weather delays, when weather prevents Contractor from continuing Work for a full day, the deadlines listed above shall be extended by the number of days of the delay caused by weather. In the event of a dispute, the County Project Manager shall determine whether there is a weather delay on a specific day. In the event of a delay in delivery of Owner supplied equipment or materials, the deadlines for Substantial and Final completion shall be extended by the number of days the delivery of the Owner supplied materials or equipment is delayed.

Bonus

E. Contractor and Owner recognize that time is of the essence as stated above and that Owner will suffer financial and other losses if the Work is not completed within the times specified above.

1. Contractor and Owner further recognize the Owner will realize financial and other benefits if the Work is completed by the time specified for Substantial

Completion. Accordingly, Owner and Contractor agree that as a bonus for timely completion, Owner shall pay Contractor $5,000 for each day prior to the date specified above for Substantial Completion (as duly adjusted pursuant to the Contract) that the Work is substantially complete. The maximum value of the bonus shall be limited to $100,000.

4. During the term of this Contract, CONTRACTOR agrees to take affirmative action to ensure equal employment opportunities. The CONTRACTOR agrees in accordance with Wisconsin Statute 111.321 and Chapter 19 of the Dane County Code of Ordinances not to discriminate on the basis of age, race, ethnicity, religion, color, gender, disability, marital status, sexual orientation, national origin, cultural differences, ancestry, physical appearance, arrest record or conviction record, military participation or membership in the national guard, state defense force or any other reserve component of the military forces of the United States, or political beliefs. Such equal opportunity shall include, but not be limited to, the following: employment, upgrading, demotion, transfer, recruitment, advertising, layoff, termination, training, rates of pay, and any other form of compensation. CONTRACTOR agrees to post in conspicuous places, available to all employees and applicants for employment, notices setting forth the provisions of this paragraph.

5. CONTRACTOR shall file an Affirmative Action Plan with the Dane County Contract Compliance Officer in accord with Chapter 19 of the Dane County Code of Ordinances. CONTRACTOR must file such plan within fifteen (15) business days of the effective date of this Contract. During the term of this Contract CONTRACTOR shall also provide copies of all announcements of employment opportunities to COUNTY'S Contract Compliance Office, and shall report annually the number of persons, by race, ethnicity, gender, and disability status, which apply for employment and, similarly classified, the number hired and number rejected.

6. During the term of this Contract, all solicitations for employment placed on CONTRACTOR'S behalf shall include a statement to the effect that CONTRACTOR is an "Equal Opportunity Employer".

7. CONTRACTOR agrees to furnish all information and reports required by COUNTY'S Contract Compliance Officer as the same relate to affirmative action and nondiscrimination, which may include any books, records, or accounts deemed appropriate to determine compliance with Chapter 19, Dane County Code of Ordinances, and the provisions of this Contract.

8. This Contract is intended to be a Contract solely between the parties hereto and for their benefit only. No part of this Contract shall be construed to add to, supplement, amend, abridge or repeal existing rights, benefits or privileges of any third party or parties including, but not limited to, employees of either of the parties.

9. The entire agreement of the parties is contained herein and this Contract supersedes any and all oral agreements and negotiations between the parties relating to the subject matter hereof. The parties expressly agree that the express terms of this Contract shall not be amended in any fashion except in writing, executed by both parties.

10. CONTRACTOR must be pre-qualified as a Best Value Contractor with Dane County Public Works Solid Waste Division before award of Contract. Subcontractors must be pre-qualified ten (10) business days prior to commencing Work under this Contract.

IN WITNESS WHEREOF, COUNTY and CONTRACTOR, by their respective authorized agents, have caused this Contract and its Schedules to be executed, effective as of the date by which all parties hereto have affixed their respective signatures, as indicated below.

* * * * * * *

FOR CONTRACTOR:

Signature ______________________ Date ______________

Printed or Typed Name and Title ______________________

Signature ______________________ Date ______________

Printed or Typed Name and Title ______________________

NOTE: If CONTRACTOR is a corporation, Secretary should attest. In accordance with IRS Regulations, unincorporated entities are required to provide either their Social Security or Employer Number in order to receive payment for services rendered.

* * * * * * *

This Contract is not valid or effectual for any purpose until approved by the appropriate authority designated below, and no work is authorized until the CONTRACTOR has been given notice to proceed by COUNTY'S Assistant Public Works Director.

FOR COUNTY:

Joseph T. Parisi, County Executive ______________________ Date ______________

Scott McDonell, County Clerk ______________________ Date ______________

COUNTY OF DANE

PUBLIC WORKS CONSTRUCTION CONTRACT

Contract No. ___________________ Bid No. 317049

Authority: 2017 RES -_________

THIS CONTRACT, made and entered into as of the date by which authorized representatives of both parties have affixed their signatures, by and between the County of Dane (hereafter referred to as "COUNTY") and ______________________________ (hereafter, "CONTRACTOR"), and

W I T N E S S E T H :

WHEREAS, COUNTY, whose address is c/o Assistant Public Works Director, 1919 Alliant Energy Center Way, Madison, WI 53713, desires to have CONTRACTOR provide Biogas Facility Construction ("the Project"); and

WHEREAS, CONTRACTOR, whose address is ______________________________________ ____ is able and willing to construct the Project, in accordance with the Construction Documents;

NOW, THEREFORE, in consideration of the above premises and the mutual covenants of the parties hereinafter set forth, the receipt and sufficiency of which is acknowledged by each party for itself, COUNTY and CONTRACTOR do agree as follows:

1. CONTRACTOR agrees to construct, for the price of $_____________ the Project and at the CONTRACTOR'S own proper cost and expense to furnish all materials, supplies, machinery, equipment, tools, superintendence labor, insurance, and other accessories and services necessary to complete the Project in accordance with the conditions and prices stated in the Bid Form, General Conditions of Contract, the drawings which include all maps, plats, plans, and other drawings and printed or written explanatory matter thereof, and the specifications therefore as prepared by Cornerstone Environmental Group LLC (hereinafter referred to as "the Architect / Engineer"), and as enumerated in the Project Manual Table of Contents, all of which are made a part hereof and collectively evidence and constitute the Contract.

2. COUNTY agrees to pay the CONTRACTOR in current funds for the performance of the Contract subject to additions and deductions, as provided in the General Conditions of Contract, and to make payments on account thereof as provided in Article entitled, "Payments to Contractor" of the General Conditions of Contract.

3. Contract Times

Time of the Essence

A. All time limits for Substantial Completion and completion and readiness for final payment as stated in the Contract Documents are of the essence of the Contract.

Contract Times: Dates

B. The Work shall be substantially completed on or before the following date: November 16, 2018.

Substantially complete means the following Work shall be completed:

1. Any start-up or commissioning required for operation,
2. Final walk through completed,
3. Development of punch-list, and
4. Final planting, seeding and mulching.

C. Work shall be completed and ready for final payment on or before the following date: November 23, 2018.

Liquidated Damages

D. Contractor and Owner recognize that time is of the essence as stated above and that Owner will suffer financial and other losses if the Work is not completed within the times specified above, plus any extensions thereof allowed in accordance with the Contract. The parties also recognize the delays, expense, and difficulties involved in proving in a legal or arbitration proceeding the actual loss suffered by Owner if the Work is not completed on time. Accordingly, instead of requiring any such proof, Owner and Contractor agree that as liquidated damages for delay (but not as a penalty):

1. Substantial Completion: Contractor shall pay Owner $10,000 for each day that expires after the time (as duly adjusted pursuant to the Contract) specified above for Substantial Completion until the Work is substantially complete.
2. Completion of Remaining Work: After Substantial Completion, if Contractor shall neglect, refuse, or fail to complete the remaining Work within the Contract Time (as duly adjusted pursuant to the Contract) for completion and readiness for final payment, Contractor shall pay Owner $5,000 for each day that expires after such time until the Work is completed and ready for final payment.
3. Liquidated damages for failing to timely attain Substantial Completion and final completion are not additive and will not be imposed concurrently.
4. Liquidated damages for failing to timely attain Substantial Completion and Final Completion shall be capped at 10% of the total contract amount.
5. There shall be no delays or adjustment to the dates for weather delays for the first 5 days of weather delays. Following the first 5 days of weather delays, when weather prevents Contractor from continuing Work for a full day, the deadlines listed above shall be extended by the number of days of the delay caused by weather. In the event of a dispute, the County Project Manager shall determine whether there is a weather delay on a specific day.

Bonus

E. Contractor and Owner recognize that time is of the essence as stated above and that Owner will suffer financial and other losses if the Work is not completed within the times specified above.

Contractor and Owner further recognize the Owner will realize financial and other benefits if the Work is completed by the time specified for Substantial Completion. Accordingly, Owner and Contractor agree that as a bonus for timely completion, Owner shall pay Contractor $5,000 for each day prior to the date specified above for Substantial Completion (as duly adjusted pursuant to the Contract) that the

Work is substantially complete. The maximum value of the bonus shall be limited to $100,000.

4. During the term of this Contract, CONTRACTOR agrees to take affirmative action to ensure equal employment opportunities. The CONTRACTOR agrees in accordance with Wisconsin Statute 111.321 and Chapter 19 of the Dane County Code of Ordinances not to discriminate on the basis of age, race, ethnicity, religion, color, gender, disability, marital status, sexual orientation, national origin, cultural differences, ancestry, physical appearance, arrest record or conviction record, military participation or membership in the national guard, state defense force or any other reserve component of the military forces of the United States, or political beliefs. Such equal opportunity shall include, but not be limited to, the following: employment, upgrading, demotion, transfer, recruitment, advertising, layoff, termination, training, rates of pay, and any other form of compensation. CONTRACTOR agrees to post in conspicuous places, available to all employees and applicants for employment, notices setting forth the provisions of this paragraph.

5. CONTRACTOR shall file an Affirmative Action Plan with the Dane County Contract Compliance Officer in accord with Chapter 19 of the Dane County Code of Ordinances. CONTRACTOR must file such plan within fifteen (15) business days of the effective date of this Contract. During the term of this Contract CONTRACTOR shall also provide copies of all announcements of employment opportunities to COUNTY'S Contract Compliance Office, and shall report annually the number of persons, by race, ethnicity, gender, and disability status, which apply for employment and, similarly classified, the number hired and number rejected.

6. During the term of this Contract, all solicitations for employment placed on CONTRACTOR'S behalf shall include a statement to the effect that CONTRACTOR is an "Equal Opportunity Employer".

7. CONTRACTOR agrees to comply with provisions of Chapter 25.13 of the Dane County Code of Ordinances, which pertains to domestic partnership benefits.

8. CONTRACTOR agrees to furnish all information and reports required by COUNTY'S Contract Compliance Officer as the same relate to affirmative action and nondiscrimination, which may include any books, records, or accounts deemed appropriate to determine compliance with Chapter 19, Dane County Code of Ordinances, and the provisions of this Contract.

9. This Contract is intended to be a Contract solely between the parties hereto and for their benefit only. No part of this Contract shall be construed to add to, supplement, amend, abridge or repeal existing rights, benefits or privileges of any third party or parties including, but not limited to, employees of either of the parties.

10. The entire agreement of the parties is contained herein and this Contract supersedes any and all oral agreements and negotiations between the parties relating to the subject matter hereof. The parties expressly agree that the express terms of this Contract shall not be amended in any fashion except in writing, executed by both parties.

11. CONTRACTOR must be pre-qualified as a Best Value Contractor with Dane County Public Works Solid Waste Division before award of Contract. Subcontractors must be pre-qualified ten (10) business days prior to commencing Work under this Contract.

IN WITNESS WHEREOF, COUNTY and CONTRACTOR, by their respective authorized agents, have caused this Contract and its Schedules to be executed, effective as of the date by which all parties hereto have affixed their respective signatures, as indicated below.

* * * * * * *

FOR CONTRACTOR:

_______________________________________ _______________
Signature Date

____
Printed or Typed Name and Title

_______________________________________ _______________
Signature Date

____
Printed or Typed Name and Title

NOTE: If CONTRACTOR is a corporation, Secretary should attest. In accordance with IRS Regulations, unincorporated entities are required to provide either their Social Security or Employer Number in order to receive payment for services rendered.

* * * * * * *

This Contract is not valid or effectual for any purpose until approved by the appropriate authority designated below, and no work is authorized until the CONTRACTOR has been given notice to proceed by COUNTY'S Assistant Public Works Director.

FOR COUNTY:

_______________________________________ _______________
Joseph T. Parisi, County Executive Date

_______________________________________ _______________
Scott McDonell, County Clerk Date

AIA® Document A310™ – 2010

Bid Bond

CONTRACTOR:
(Name, legal status and address)

SURETY:
(Name, legal status and principal place of business)

This document has important legal consequences. Consultation with an attorney is encouraged with respect to its completion or modification.

Any singular reference to Contractor, Surety, Owner or other party shall be considered plural where applicable.

OWNER:
(Name, legal status and address)

BOND AMOUNT:

PROJECT:
(Name, location or address, and Project number, if any)

The Contractor and Surety are bound to the Owner in the amount set forth above, for the payment of which the Contractor and Surety bind themselves, their heirs, executors, administrators, successors and assigns, jointly and severally, as provided herein. The conditions of this Bond are such that if the Owner accepts the bid of the Contractor within the time specified in the bid documents, or within such time period as may be agreed to by the Owner and Contractor, and the Contractor either (1) enters into a contract with the Owner in accordance with the terms of such bid, and gives such bond or bonds as may be specified in the bidding or Contract Documents, with a surety admitted in the jurisdiction of the Project and otherwise acceptable to the Owner, for the faithful performance of such Contract and for the prompt payment of labor and material furnished in the prosecution thereof; or (2) pays to the Owner the difference, not to exceed the amount of this Bond, between the amount specified in said bid and such larger amount for which the Owner may in good faith contract with another party to perform the work covered by said bid, then this obligation shall be null and void, otherwise to remain in full force and effect. The Surety hereby waives any notice of an agreement between the Owner and Contractor to extend the time in which the Owner may accept the bid. Waiver of notice by the Surety shall not apply to any extension exceeding sixty (60) days in the aggregate beyond the time for acceptance of bids specified in the bid documents, and the Owner and Contractor shall obtain the Surety's consent for an extension beyond sixty (60) days.

If this Bond is issued in connection with a subcontractor's bid to a Contractor, the term Contractor in this Bond shall be deemed to be Subcontractor and the term Owner shall be deemed to be Contractor.

When this Bond has been furnished to comply with a statutory or other legal requirement in the location of the Project, any provision in this Bond conflicting with said statutory or legal requirement shall be deemed deleted herefrom and provisions conforming to such statutory or other legal requirement shall be deemed incorporated herein. When so furnished, the intent is that this Bond shall be construed as a statutory bond and not as a common law bond.

Signed and sealed this day of

	(Contractor as Principal) *(Seal)*
(Witness)	*(Title)*
	(Surety) *(Seal)*
(Witness)	*(Title)*

CAUTION: You should sign an original AIA Contract Document, on which this text appears in RED. An original assures that changes will not be obscured.

Init.

/

AIA® Document A312™ – 2010

Performance Bond

CONTRACTOR:
(Name, legal status and address)

SURETY:
(Name, legal status and principal place of business)

This document has important legal consequences. Consultation with an attorney is encouraged with respect to its completion or modification.

Any singular reference to Contractor, Surety, Owner or other party shall be considered plural where applicable.

AIA Document A312–2010 combines two separate bonds, a Performance Bond and a Payment Bond, into one form. This is not a single combined Performance and Payment Bond.

OWNER:
(Name, legal status and address)

CONSTRUCTION CONTRACT
Date:

Amount:

Description:
(Name and location)

BOND
Date:
(Not earlier than Construction Contract Date)

Amount:

Modifications to this Bond: ☐ None ☐ See Section 16

CONTRACTOR AS PRINCIPAL
Company: *(Corporate Seal)*

Signature: ______________________
Name Nam
and Title:

SURETY
Company: *(Corporate Seal)*

Signature: ______________________
e
and Title:

(Any additional signatures appear on the last page of this Performance Bond.)

(FOR INFORMATION ONLY — Name, address and telephone)
AGENT or BROKER:

OWNER'S REPRESENTATIVE:
(Architect, Engineer or other party:)

Init.

/

§ 1 The Contractor and Surety, jointly and severally, bind themselves, their heirs, executors, administrators, successors and assigns to the Owner for the performance of the Construction Contract, which is incorporated herein by reference.

§ 2 If the Contractor performs the Construction Contract, the Surety and the Contractor shall have no obligation under this Bond, except when applicable to participate in a conference as provided in Section 3.

§ 3 If there is no Owner Default under the Construction Contract, the Surety's obligation under this Bond shall arise after

.1 the Owner first provides notice to the Contractor and the Surety that the Owner is considering declaring a Contractor Default. Such notice shall indicate whether the Owner is requesting a conference among the Owner, Contractor and Surety to discuss the Contractor's performance. If the Owner does not request a conference, the Surety may, within five (5) business days after receipt of the Owner's notice, request such a conference. If the Surety timely requests a conference, the Owner shall attend. Unless the Owner agrees otherwise, any conference requested under this Section 3.1 shall be held within ten (10) business days of the Surety's receipt of the Owner's notice. If the Owner, the Contractor and the Surety agree, the Contractor shall be allowed a reasonable time to perform the Construction Contract, but such an agreement shall not waive the Owner's right, if any, subsequently to declare a Contractor Default;

.2 the Owner declares a Contractor Default, terminates the Construction Contract and notifies the Surety; and

.3 the Owner has agreed to pay the Balance of the Contract Price in accordance with the terms of the Construction Contract to the Surety or to a contractor selected to perform the Construction Contract.

§ 4 Failure on the part of the Owner to comply with the notice requirement in Section 3.1 shall not constitute a failure to comply with a condition precedent to the Surety's obligations, or release the Surety from its obligations, except to the extent the Surety demonstrates actual prejudice.

§ 5 When the Owner has satisfied the conditions of Section 3, the Surety shall promptly and at the Surety's expense take one of the following actions:

§ 5.1 Arrange for the Contractor, with the consent of the Owner, to perform and complete the Construction Contract;

§ 5.2 Undertake to perform and complete the Construction Contract itself, through its agents or independent contractors;

§ 5.3 Obtain bids or negotiated proposals from qualified contractors acceptable to the Owner for a contract for performance and completion of the Construction Contract, arrange for a contract to be prepared for execution by the Owner and a contractor selected with the Owner's concurrence, to be secured with performance and payment bonds executed by a qualified surety equivalent to the bonds issued on the Construction Contract, and pay to the Owner the amount of damages as described in Section 7 in excess of the Balance of the Contract Price incurred by the Owner as a result of the Contractor Default; or

§ 5.4 Waive its right to perform and complete, arrange for completion, or obtain a new contractor and with reasonable promptness under the circumstances:

.1 After investigation, determine the amount for which it may be liable to the Owner and, as soon as practicable after the amount is determined, make payment to the Owner; or

.2 Deny liability in whole or in part and notify the Owner, citing the reasons for denial.

§ 6 If the Surety does not proceed as provided in Section 5 with reasonable promptness, the Surety shall be deemed to be in default on this Bond seven days after receipt of an additional written notice from the Owner to the Surety demanding that the Surety perform its obligations under this Bond, and the Owner shall be entitled to enforce any remedy available to the Owner. If the Surety proceeds as provided in Section 5.4, and the Owner refuses the payment or the Surety has denied liability, in whole or in part, without further notice the Owner shall be entitled to enforce any remedy available to the Owner.

§ 7 If the Surety elects to act under Section 5.1, 5.2 or 5.3, then the responsibilities of the Surety to the Owner shall not be greater than those of the Contractor under the Construction Contract, and the responsibilities of the Owner to the Surety shall not be greater than those of the Owner under the Construction Contract. Subject to the commitment by the Owner to pay the Balance of the Contract Price, the Surety is obligated, without duplication, for

.1 the responsibilities of the Contractor for correction of defective work and completion of the Construction Contract;

.2 additional legal, design professional and delay costs resulting from the Contractor's Default, and resulting from the actions or failure to act of the Surety under Section 5; and

.3 liquidated damages, or if no liquidated damages are specified in the Construction Contract, actual damages caused by delayed performance or non-performance of the Contractor.

§ 8 If the Surety elects to act under Section 5.1, 5.3 or 5.4, the Surety's liability is limited to the amount of this Bond.

§ 9 The Surety shall not be liable to the Owner or others for obligations of the Contractor that are unrelated to the Construction Contract, and the Balance of the Contract Price shall not be reduced or set off on account of any such unrelated obligations. No right of action shall accrue on this Bond to any person or entity other than the Owner or its heirs, executors, administrators, successors and assigns.

§ 10 The Surety hereby waives notice of any change, including changes of time, to the Construction Contract or to related subcontracts, purchase orders and other obligations.

§ 11 Any proceeding, legal or equitable, under this Bond may be instituted in any court of competent jurisdiction in the location in which the work or part of the work is located and shall be instituted within two years after a declaration of Contractor Default or within two years after the Contractor ceased working or within two years after the Surety refuses or fails to perform its obligations under this Bond, whichever occurs first. If the provisions of this Paragraph are void or prohibited by law, the minimum period of limitation available to sureties as a defense in the jurisdiction of the suit shall be applicable.

§ 12 Notice to the Surety, the Owner or the Contractor shall be mailed or delivered to the address shown on the page on which their signature appears.

§ 13 When this Bond has been furnished to comply with a statutory or other legal requirement in the location where the construction was to be performed, any provision in this Bond conflicting with said statutory or legal requirement shall be deemed deleted herefrom and provisions conforming to such statutory or other legal requirement shall be deemed incorporated herein. When so furnished, the intent is that this Bond shall be construed as a statutory bond and not as a common law bond.

§ 14 Definitions

§ 14.1 Balance of the Contract Price. The total amount payable by the Owner to the Contractor under the Construction Contract after all proper adjustments have been made, including allowance to the Contractor of any amounts received or to be received by the Owner in settlement of insurance or other claims for damages to which the Contractor is entitled, reduced by all valid and proper payments made to or on behalf of the Contractor under the Construction Contract.

§ 14.2 Construction Contract. The agreement between the Owner and Contractor identified on the cover page, including all Contract Documents and changes made to the agreement and the Contract Documents.

§ 14.3 Contractor Default. Failure of the Contractor, which has not been remedied or waived, to perform or otherwise to comply with a material term of the Construction Contract.

§ 14.4 Owner Default. Failure of the Owner, which has not been remedied or waived, to pay the Contractor as required under the Construction Contract or to perform and complete or comply with the other material terms of the Construction Contract.

§ 14.5 Contract Documents. All the documents that comprise the agreement between the Owner and Contractor.

§ 15 If this Bond is issued for an agreement between a Contractor and subcontractor, the term Contractor in this Bond shall be deemed to be Subcontractor and the term Owner shall be deemed to be Contractor.

§ 16 Modifications to this bond are as follows:

(Space is provided below for additional signatures of added parties, other than those appearing on the cover page.)

CONTRACTOR AS PRINCIPAL		**SURETY**	
Company:	*(Corporate Seal)*	Company:	*(Corporate Seal)*
Signature:	______________________	Signature:	______________________
Name and Title:		Name and Title:	
Address		Address	

CAUTION: You should sign an original AIA Contract Document, on which this text appears in RED. An original assures that changes will not be obscured.

AIA® Document A312™ – 2010

Payment Bond

CONTRACTOR:
(Name, legal status and address)

SURETY:
(Name, legal status and principal place of business)

OWNER:
(Name, legal status and address)

This document has important legal consequences. Consultation with an attorney is encouraged with respect to its completion or modification.

Any singular reference to Contractor, Surety, Owner or other party shall be considered plural where applicable.

AIA Document A312–2010 combines two separate bonds, a Performance Bond and a Payment Bond, into one form. This is not a single combined Performance and Payment Bond.

CONSTRUCTION CONTRACT
Date:

Amount:

Description:
(Name and location)

BOND
Date:
(Not earlier than Construction Contract Date)

Amount:

Modifications to this Bond: ☐ None ☐ See Section 18

CONTRACTOR AS PRINCIPAL
Company: *(Corporate Seal)*

Signature: ______________________
Name and Title:

SURETY
Company: *(Corporate Seal)*

Signature: ______________________
Name and Title:

(Any additional signatures appear on the last page of this Payment Bond.)

(FOR INFORMATION ONLY — Name, address and telephone)

AGENT or BROKER:

OWNER'S REPRESENTATIVE:
(Architect, Engineer or other party:)

§ 1 The Contractor and Surety, jointly and severally, bind themselves, their heirs, executors, administrators, successors and assigns to the Owner to pay for labor, materials and equipment furnished for use in the performance of the Construction Contract, which is incorporated herein by reference, subject to the following terms.

§ 2 If the Contractor promptly makes payment of all sums due to Claimants, and defends, indemnifies and holds harmless the Owner from claims, demands, liens or suits by any person or entity seeking payment for labor, materials or equipment furnished for use in the performance of the Construction Contract, then the Surety and the Contractor shall have no obligation under this Bond.

§ 3 If there is no Owner Default under the Construction Contract, the Surety's obligation to the Owner under this Bond shall arise after the Owner has promptly notified the Contractor and the Surety (at the address described in Section 13) of claims, demands, liens or suits against the Owner or the Owner's property by any person or entity seeking payment for labor, materials or equipment furnished for use in the performance of the Construction Contract and tendered defense of such claims, demands, liens or suits to the Contractor and the Surety.

§ 4 When the Owner has satisfied the conditions in Section 3, the Surety shall promptly and at the Surety's expense defend, indemnify and hold harmless the Owner against a duly tendered claim, demand, lien or suit.

§ 5 The Surety's obligations to a Claimant under this Bond shall arise after the following:

§ 5.1 Claimants, who do not have a direct contract with the Contractor,

- **.1** have furnished a written notice of non-payment to the Contractor, stating with substantial accuracy the amount claimed and the name of the party to whom the materials were, or equipment was, furnished or supplied or for whom the labor was done or performed, within ninety (90) days after having last performed labor or last furnished materials or equipment included in the Claim; and
- **.2** have sent a Claim to the Surety (at the address described in Section 13).

§ 5.2 Claimants, who are employed by or have a direct contract with the Contractor, have sent a Claim to the Surety (at the address described in Section 13).

§ 6 If a notice of non-payment required by Section 5.1.1 is given by the Owner to the Contractor, that is sufficient to satisfy a Claimant's obligation to furnish a written notice of non-payment under Section 5.1.1.

§ 7 When a Claimant has satisfied the conditions of Sections 5.1 or 5.2, whichever is applicable, the Surety shall promptly and at the Surety's expense take the following actions:

§ 7.1 Send an answer to the Claimant, with a copy to the Owner, within sixty (60) days after receipt of the Claim, stating the amounts that are undisputed and the basis for challenging any amounts that are disputed; and

§ 7.2 Pay or arrange for payment of any undisputed amounts.

§ 7.3 The Surety's failure to discharge its obligations under Section 7.1 or Section 7.2 shall not be deemed to constitute a waiver of defenses the Surety or Contractor may have or acquire as to a Claim, except as to undisputed amounts for which the Surety and Claimant have reached agreement. If, however, the Surety fails to discharge its obligations under Section 7.1 or Section 7.2, the Surety shall indemnify the Claimant for the reasonable attorney's fees the Claimant incurs thereafter to recover any sums found to be due and owing to the Claimant.

§ 8 The Surety's total obligation shall not exceed the amount of this Bond, plus the amount of reasonable attorney's fees provided under Section 7.3, and the amount of this Bond shall be credited for any payments made in good faith by the Surety.

§ 9 Amounts owed by the Owner to the Contractor under the Construction Contract shall be used for the performance of the Construction Contract and to satisfy claims, if any, under any construction performance bond. By the Contractor furnishing and the Owner accepting this Bond, they agree that all funds earned by the Contractor in the performance of the Construction Contract are dedicated to satisfy obligations of the Contractor and Surety under this Bond, subject to the Owner's priority to use the funds for the completion of the work.

§ 10 The Surety shall not be liable to the Owner, Claimants or others for obligations of the Contractor that are unrelated to the Construction Contract. The Owner shall not be liable for the payment of any costs or expenses of any Claimant under this Bond, and shall have under this Bond no obligation to make payments to, or give notice on behalf of, Claimants or otherwise have any obligations to Claimants under this Bond.

§ 11 The Surety hereby waives notice of any change, including changes of time, to the Construction Contract or to related subcontracts, purchase orders and other obligations.

§ 12 No suit or action shall be commenced by a Claimant under this Bond other than in a court of competent jurisdiction in the state in which the project that is the subject of the Construction Contract is located or after the expiration of one year from the date (1) on which the Claimant sent a Claim to the Surety pursuant to Section 5.1.2 or 5.2, or (2) on which the last labor or service was performed by anyone or the last materials or equipment were furnished by anyone under the Construction Contract, whichever of (1) or (2) first occurs. If the provisions of this Paragraph are void or prohibited by law, the minimum period of limitation available to sureties as a defense in the jurisdiction of the suit shall be applicable.

§ 13 Notice and Claims to the Surety, the Owner or the Contractor shall be mailed or delivered to the address shown on the page on which their signature appears. Actual receipt of notice or Claims, however accomplished, shall be sufficient compliance as of the date received.

§ 14 When this Bond has been furnished to comply with a statutory or other legal requirement in the location where the construction was to be performed, any provision in this Bond conflicting with said statutory or legal requirement shall be deemed deleted herefrom and provisions conforming to such statutory or other legal requirement shall be deemed incorporated herein. When so furnished, the intent is that this Bond shall be construed as a statutory bond and not as a common law bond.

§ 15 Upon request by any person or entity appearing to be a potential beneficiary of this Bond, the Contractor and Owner shall promptly furnish a copy of this Bond or shall permit a copy to be made.

§ 16 Definitions

§ 16.1 Claim. A written statement by the Claimant including at a minimum:

.1 the name of the Claimant;
.2 the name of the person for whom the labor was done, or materials or equipment furnished;
.3 a copy of the agreement or purchase order pursuant to which labor, materials or equipment was furnished for use in the performance of the Construction Contract;
.4 a brief description of the labor, materials or equipment furnished;
.5 the date on which the Claimant last performed labor or last furnished materials or equipment for use in the performance of the Construction Contract;
.6 the total amount earned by the Claimant for labor, materials or equipment furnished as of the date of the Claim;
.7 the total amount of previous payments received by the Claimant; and
.8 the total amount due and unpaid to the Claimant for labor, materials or equipment furnished as of the date of the Claim.

§ 16.2 Claimant. An individual or entity having a direct contract with the Contractor or with a subcontractor of the Contractor to furnish labor, materials or equipment for use in the performance of the Construction Contract. The term Claimant also includes any individual or entity that has rightfully asserted a claim under an applicable mechanic's lien or similar statute against the real property upon which the Project is located. The intent of this Bond shall be to include without limitation in the terms "labor, materials or equipment" that part of water, gas, power, light, heat, oil, gasoline, telephone service or rental equipment used in the Construction Contract, architectural and engineering services required for performance of the work of the Contractor and the Contractor's subcontractors, and all other items for which a mechanic's lien may be asserted in the jurisdiction where the labor, materials or equipment were furnished.

§ 16.3 Construction Contract. The agreement between the Owner and Contractor identified on the cover page, including all Contract Documents and all changes made to the agreement and the Contract Documents.

§ 16.4 Owner Default. Failure of the Owner, which has not been remedied or waived, to pay the Contractor as required under the Construction Contract or to perform and complete or comply with the other material terms of the Construction Contract.

§ 16.5 Contract Documents. All the documents that comprise the agreement between the Owner and Contractor.

§ 17 If this Bond is issued for an agreement between a Contractor and subcontractor, the term Contractor in this Bond shall be deemed to be Subcontractor and the term Owner shall be deemed to be Contractor.

§ 18 Modifications to this bond are as follows:

(Space is provided below for additional signatures of added parties, other than those appearing on the cover page.)

CONTRACTOR AS PRINCIPAL		**SURETY**	
Company:	*(Corporate Seal)*	Company:	*(Corporate Seal)*
Signature:	______________________	Signature:	______________________
Name and Title:		Name and Title:	
Address		Address	

CAUTION: You should sign an original AIA Contract Document, on which this text appears in RED. An original assures that changes will not be obscured.

EQUAL BENEFITS COMPLIANCE PAYMENT CERTIFICATION FORM

PURPOSE

25.13 of the Dane County Ordinance requires that each contractor receiving payment for contracted services must certify that he or she has complied fully with the requirements of Chapter 25.13 "Equal Benefits Requirement" of the Dane County Ordinances. Such certification must be submitted prior to the final payment on the contract.

This form should be included with a copy of the final contract invoice forwarded to your contract representative at Dane County.

CERTIFICATION

I, ____ certify that
Printed or Typed Name and Title

____
Printed or Typed Name of Contractor

has complied fully with the requirements of Chapter 25.13 of the Dane County Ordinances "Equal Benefits Requirements".

Signed ____

Date ____________________________________

For questions on this form, please contact Chuck Hicklin at 608-266-4109 or your contract representative at Dane County.

GENERAL CONDITIONS OF CONTRACT

TABLE OF CONTENTS

1. CONSTRUCTION DOCUMENTS

A. Construction Documents, listed in Table of Contents of this Specification volume shall form part of this Contract and provisions of Construction Documents shall be as binding upon parties as if they were fully set forth in Contract itself.

B. These shall also be considered as part of Construction Documents: Addenda, including additions and modifications incorporated in such addenda before execution of Contract; requests for information; construction bulletins; change orders; and written interpretations by Architect / Engineer or Public Works Project Manager that are made after execution of Contract.

C. Construction Documents are complementary, and what is required by one shall be as binding as if required by all. Intent of Construction Documents is to include all labor, materials and equipment necessary for proper execution of the Work.

2. DEFINITIONS

A. These terms as used in this Contract are respectively defined as follows:
1. All uses of term “County” in Construction Documents shall mean Dane County.
2. All uses of term “Department” in Construction Documents shall mean Department of Public Works, Highway & Transportation, which is a unit of Dane County government. Department is County agency overseeing Contract with Contractor.
3. Public Works Project Manager is appointed by and responsible to Department. Public Works Project Manager has authority to act on behalf of Department and will sign change orders, payment requests and other administrative matters related to projects.
4. Public Works Project Manager is responsible for supervision, administration and management of field operations involved in construction phase of this Work.
5. Term “Work” includes all labor, equipment and materials necessary to produce project required by Construction Documents.
6. Term “Substantial Completion” is date when project or specified area of project is certified by Architect / Engineer that construction is sufficiently completed, in accordance with Construction Documents, and as modified by any subsequent changes agreed to by parties, so that County may occupy project or specified area of project for use for which it was intended subject to permit approval for occupancy.
7. Contractor is person, firm, or corporation with whom County makes Contract. Though multiple contracts may be involved, Construction Documents treat them throughout as if each were of singular number.

3. ADDITIONAL INSTRUCTIONS AND DRAWINGS

A. Contractor may be furnished additional instructions and detail drawings as necessary to carry out the Work included in Contract. Additional drawings and instructions thus supplied to Contractor will coordinate with Construction Documents and will be so prepared that they can be reasonably interpreted as part thereof. Contractor shall carry out the Work in accordance with additional detail drawings and instructions.

4. SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

A. Unless otherwise specified, Contractor shall submit three (3) copies of all Shop Drawings for each submission, until receiving final approval. After final approval, provide five (5) additional copies for distribution and such other copies as may be required.

B. Contractor shall submit, on an on-going basis and as directed, Product Data such as brochures that shall contain catalog cuts and specifications of all furnished mechanical and electrical equipment. After Architect / Engineer's approval, one (1) copy shall remain in Architect / Engineer's file, one (1) kept at Department's office and one (1) kept at job site by Contractor for reference purposes.

C. Samples shall consist of physical examples furnished by Contractor in sufficient size and quantity to illustrate materials, equipment or workmanship, and to establish standards to compare the Work.
   1. Submit Samples in sufficient quantity (minimum of two (2)) to permit Architect / Engineer to make all necessary tests and of adequate size showing quality, type, color range, finish, and texture. Label each Sample stating material, type, color, thickness, size, project name, and Contractor's name.
   2. Submit transmittal letter requesting approval, and prepay transportation charges to Architect / Engineer's office on samples forwarded.
   3. Materials installed shall match approved Samples.

D. Contractor shall review Shop Drawings and place their dated stamp thereon to evidence their review and approval and shall submit with reasonable promptness and in orderly sequence to cause no delay in the Work or in work of any other contractor. At time of submission, Contractor shall inform Architect / Engineer in writing of any deviation in Shop Drawings or Samples from requirements of Construction Documents. Architect / Engineer will not consider partial lists.

E. Architect / Engineer will review and approve or reject Shop Drawings with reasonable promptness to cause no delay. Architect / Engineer's approval shall not relieve Contractor from responsibility for errors or omissions in Shop Drawings.

F. Contractor shall not commence any work requiring Shop Drawing, Product Data or Sample submission until Architect / Engineer has approved submission. All such work shall be in accordance with approved Shop Drawings, Product Data and Samples.

G. Contractor shall keep on site of the Work, approved or conformed copy of Shop Drawings and shall at all times give Department access thereto.

H. By stamping and submitting Shop Drawings, Product Data and Samples, Contractor thereby represents that he or she has or will determine and verify all field measurements, field construction criteria, materials, catalog numbers, and similar data and that he or she has checked and coordinated each Shop Drawing, Product Data and Sample with requirements of the Work and of Construction Documents. Architect / Engineer shall return without examination, Shop Drawings, Product Data and Samples not so noted.

I. All Shop Drawings from any one Contractor should be numbered consecutively and on cover sheet shall bear name and location of project, name of Contractor, date of submittal and date of each correction or revision and associated Specification section and page number.

5. CUTTING AND PATCHING

A. Contractor shall be responsible for all cutting, fitting or patching required to complete the Work or to make its parts fit together properly.

B. Contractor shall not damage or endanger portion of the Work or fully or partially completed construction of County or separate contractors by cutting, patching or otherwise altering such construction, or by excavation. Contractor shall not cut or otherwise alter such construction by County or separate contractor except with written consent of County and of such separate contractor; such consent shall not be unreasonably withheld. Contractor shall not withhold unreasonably from County or separate contractor, Contractor's consent to cutting or otherwise altering the Work.

6. CLEANING UP

A. Contractor shall keep premises and surrounding area free from accumulation of waste materials or rubbish caused by operations under Contract. Contractor shall remove from and about the Work waste materials, rubbish, Contractor's tools, construction equipment, machinery, and surplus materials at completion of the Work. Contractor shall maintain streets and sidewalks around the Work site in clean condition. Contractor shall remove all spillage and prevent tracking of spillage arising from performance of the Work, into, out of, and within the Work site. Contractor shall establish regular maintenance program of sweeping, vacuuming and / or hosing to minimize accumulation of dirt and dust upon such areas.

B. If Contractor fails to clean up as directed in Construction Documents, County may do so and shall charge Contractor cost thereof.

C. Contractor shall be responsible for broken windows and glass, and at completion of the Work shall replace such damaged or broken windows and glass. After replacing damaged or broken windows and glass, Contractor shall remove all labels, wash and polish both sides of all windows and glass.

D. In addition to general cleaning (sweeping, vacuuming and / or hosing, as is appropriate to work surface), Contractor shall perform following final cleaning for all trades at completion of the Work:

1. Remove temporary protections;
2. Remove marks, stains, fingerprints and other soil or dirt from painted, decorated and finished woodwork and wall surfaces;
3. Remove spots, plaster, soil and paint from ceramic tile, marble and other finished materials, and wash or wipe clean;
4. Clean fixtures, cabinet work and equipment, removing stains, paint, dirt and dust, and leave same in undamaged, new condition;
5. Clean aluminum in accordance with recommendations of manufacturer; and
6. Clean resilient floors thoroughly with well-rinsed mop containing only enough moisture to clean off any surface dirt or dust and buff dry by machine to bring surfaces to sheen.

7. USE OF SITE

A. Contractor shall provide County and Architect / Engineer access to the Work under all circumstances.

B. Contractor shall confine operations at site to areas permitted by County, law, ordinance, permits and Construction Documents and shall not unreasonably encumber site with materials or equipment. Contractor shall assure free, convenient, unencumbered, direct and safe access to all properties adjacent to the Work for County, its employees, invitees and guests.

8. MATERIALS AND WORKMANSHIP

A. Contractor shall perform all work and furnish all supplies and materials, machinery, equipment, facilities and means, necessary to complete the Work required by this Contract, within time specified, in accordance with provisions of Construction Documents.

B. All equipment and materials incorporated in the Work covered by this Contract are to be new; use recycled and / or recovered materials to extent that such use is technically and economically feasible. Recovered materials are products recovered from solid waste in form identical to original form for use that is same as, or similar to original use. Recycled materials are products manufactured from solid waste.

C. If requested, Contractor shall furnish satisfactory evidence as to kind and quality of construction materials proposed or used. Contractor shall furnish to Architect / Engineer, for approval, manufacturer name and model, performance capacities and other pertinent information of machinery, mechanical, electrical or other types of equipment, which Contractor plans to install.

D. If not otherwise provided, materials and labor called for in this Contract shall be provided and performed in accordance with established practice and standards recognized by Architects, Engineers, Department, and construction industry.

E. Reference to "Standard" specifications of any association or manufacturer, or codes of County authorities, intends most recent printed edition or catalog in effect on date that corresponds with date of Construction Documents.

F. Whenever reference is made in Specifications that work shall be "performed", "applied", in accordance with "manufacturer's directions or instructions", Contractor to whom those instructions are directed shall furnish three (3) printed copies of such instructions to Architect / Engineer before execution of the Work.

9. CONTRACTOR'S TITLE TO MATERIALS

A. Contractor or any subcontractor shall not purchase materials or supplies for the Work subject to any chattel mortgage or under conditional sale contract or other agreement by which seller retains interest. Contractor warrants that all materials and supplies used in the Work are free from all liens, claims or encumbrances and Contractor has good title to them.

10. "OR EQUAL" CLAUSE

A. Whenever equipment or materials are identified on Drawings or in Specifications by reference to manufacturer's or vendor's name, trade name, catalog number, and other identifying information, it is intended to establish standards; and any equipment or material of other manufacturers and vendors which will perform adequately duties imposed by general design will be considered equally accepted provided equipment or material so proposed is, in opinion of Architect / Engineer, of equal substance and function. Architect / Engineer and Department shall provide written approval before Contractor may purchase or install it.

B. Equipment or materials of manufacturers, other than those named, may be used only upon following conditions:
   1. That, in opinion of Architect / Engineer and Department, proposed material or equipment item is fully equal or superior (in design, materials, construction, workmanship,

performance, finish, etc.) to named item. No compromise in quality level, however small, is acceptable.

2. That, in substituting materials or equipment, Contractor assumes responsibility for any changes in system or for modifications required in adjacent or related work to accommodate such substitution despite Architect / Engineer's and Department's approval, and all costs growing out of approval of "or equal" items shall be responsibility of Contractor. No extra costs resulting from such approval shall become responsibility of Department, Architect / Engineer or any other separate Contractor.
3. It shall be understood that use of materials or equipment other than those specified, or approved equal by Architect / Engineer and Department, shall constitute violation of Contract, and that Architect / Engineer and Department shall have right to require removal of such materials or equipment and their replacement with specified materials or equipment at Contractor's expense.
4. Product and manufacturer named first in Specifications or on information shown on Drawings is basis of selection of manufactured items and equipment, particularly mechanical equipment. In using other than first named products or manufacturers, including those specified as additionally approved or acceptable, Contractor assumes responsibility for any changes in system and for modifications in any work required to accommodate them. Architect / Engineer's approval of such additionally acceptable products or manufacturers, either in Specifications or in Addendum, does not relieve Contractor from obligation to coordinate such optional products with other Contractors, whose work may be affected by them, and to pay all additional costs resulting from their inclusion into the Work. Contractor's liability shall include payment of Architect / Engineer's fees for any additional services made necessary by or directly connected to such product changes. No extra costs resulting from such changes shall become responsibility of Department, Architect / Engineer or any other separate Contractor.

C. No request for approval of "or equal" materials will be entertained except from Contractor. Identify any request for substitution as substitution on Contractor's letter of transmittal and give reasons for substitution. Department may in its sole discretion allow substitutions of materials.

11. PATENTS AND ROYALTIES

A. If Contractor uses any design, device or material covered by letters, patent or copyright, it is mutually agreed and understood, that, without exception, contract prices shall include all royalties or costs arising from use of such design, device or materials, in any way involved in the Work.

B. Contractor shall indemnify and save harmless County from any and all claims for infringement by reason of use of such patent or copyright in connection with the Work agreed to be performed under this Contract, and shall indemnify County for any cost, expense or damage which it may be obliged to pay by reason of such infringement at any time during prosecution of the Work or after completion of the Work.

12. SURVEYS, PERMITS, REGULATIONS AND TAXES

A. Department will furnish to Contractor all site, topography and property surveys necessary for execution of the Work.

B. Contractor shall procure all permits, licenses and approvals necessary for execution of this Contract.

C. Contractor shall give all notices and comply with all State of Wisconsin, Federal and local laws, codes, rules and regulations relating to performance of the Work, protection of adjacent property, and maintenance of passageways, guard fences or other protective facilities.

D. Contractor shall pay all Sales, Consumer, Use and other similar taxes required by law.

E. Contractor shall promptly notify Architect / Engineer of any variances of Drawings or Specifications with that of any State of Wisconsin, federal or local law, code, rule or regulation. Upon such notification, Architect / Engineer will require correction of variance to comply with applicable law, code, rule or regulation at no additional cost to Contractor.

F. Work under this Contract shall comply with all applicable State of Wisconsin, Federal and local laws, codes and regulations.

G. Contractor shall pay charges for water, sewer and other utility connections made by municipalities where required by Specifications.

13. CONTRACTOR'S OBLIGATIONS AND SUPERINTENDENCE

A. Contractor shall provide and pay for all materials, labor, tools, equipment, transportation and superintendence necessary to execute, complete and deliver the Work within specified time. Contractor agrees to secure at their own expense all personnel necessary to carry out the Work. Such personnel shall not be deemed County employees nor shall they have or be deemed to have any direct contractual relationship with County.

B. Performance of any work necessary after regular working hours, on Sundays or Legal Holidays shall be without additional expense to County. Performance of any work at site at other than normal working hours must be coordinated with Public Works Project Manager.

C. Contractor shall furnish, erect, maintain and remove such temporary works as may be required.

D. Contractor shall observe, comply with, and be subject to all terms, conditions, requirements and limitations of Construction Documents.

E. At the Work site, Contractor shall give personal superintendence to the Work or shall employ construction superintendent or foreman, experienced in character of work covered by Contract, who shall have full authority to act for Contractor. Understand that such superintendent or foreman shall be acceptable to Architect / Engineer and Department.

F. Remove from project or take other corrective action upon notice from Architect / Engineer or Department for Contractor's employees whose work is considered by Architect / Engineer or Department to be unsatisfactory, careless, incompetent, unskilled or otherwise objectionable.

G. Contractor and subcontractors shall be required to conform to Labor Laws of State of Wisconsin and various acts amendatory and supplementary thereto and to other laws, ordinances and legal requirements applicable to the Work.

H. Presence and observation of the Work by Architect / Engineer or Public Works Project Manager shall not relieve Contractor of any obligations.

14. WEATHER CONDITIONS

A. In event of temporary suspension of work, or during inclement weather, or whenever Architect / Engineer shall direct, Contractor shall, and shall cause subcontractors to protect carefully all work and materials against damage or injury from weather. If, in opinion of Architect / Engineer or Department, any work or materials that have been damaged or injured due to failure on part of Contractor or any subcontractors so to protect the Work, such materials shall be removed and replaced at expense of Contractor.

15. PROTECTION OF WORK AND PROPERTY

A. Contractor shall at all times safely guard County's property from injury or loss in connection with this Contract. Contractor shall at all times safely guard and protect the Work, and adjacent property, from damage. Contractor shall replace or make good any such damage, loss or injury unless such is caused directly by errors contained in Contract, or by County, or County's duly authorized representative.

B. Contractor may act diligently, without previous instructions from Architect / Engineer and / or Department, in emergency that threatens loss or injury of property, or safety of life. Contractor shall notify Architect / Engineer and / or Department immediately thereafter. Promptly submit any claim for compensation by Contractor due to such extra work to Architect / Engineer and / or Department for approval as provided for in Article 18 herein.

16. INSPECTION AND TESTING OF MATERIALS

A. Authorized representatives and agents of County government shall have access at all times to the Work wherever it is in preparation or progress and Contractor shall provide facilities for such access and for inspection.

B. Should it be considered necessary or advisable at any time before final acceptance of the Work to make examination of work already completed, by removing or tearing out same, Contractor shall upon request, promptly furnish all necessary facilities, labor and materials. If such work is found to be defective in any aspect, due to fault of Contractor or subcontractors thereof, Contractor shall assume all expenses of such examination and of satisfactory reconstruction. Contractor will be reimbursed for such examination and replacement in accordance with Article 18 - A.3., of these General Conditions of Contract if such work is found to meet requirements of Contract.

C. If Specifications, Architect / Engineer's, or Public Works Project Manager's instructions require any work to be specially tested or approved, Contractor shall give Architect / Engineer and Public Works Project Manager timely notice of its readiness for testing or inspection. Test all materials and equipment requiring testing in accordance with accepted or specified standards, as applicable. Architect / Engineer shall recommend laboratory or inspection agency and Department will select and pay for all initial laboratory inspection services. Should retesting be required, due to failure of initial testing, cost of such retesting shall be borne by Contractor.

D. Cost of any testing performed by manufacturers or Contractor for substantiating acceptability of proposed substitution of materials and equipment, or necessary conformance testing in conjunction with manufacturing processes or factory assemblage, shall be borne by Contractor or manufacturer responsible.

17. REPORTS, RECORDS AND DATA

A. Contractor shall submit to Architect / Engineer and Public Works Project Manager such schedule of quantities and costs, progress schedules, payrolls, reports, estimates, invoices, records and other data as either may request concerning work performed or to be performed under this Contract.

18. CHANGES IN THE WORK

A. Make no changes, except in cases of emergency, in the Work covered by approved Construction Documents without having prior written approval of Department. Charges or credits for the Work covered by approved change shall be determined by one of these methods:

1. Unit bid prices previously approved.
2. Agreed lump sum based on actual cost of:
   a) Labor, including foremen, and all fringe benefits that are associated with their wages.
   b) Materials entering permanently into the Work.
   c) Ownership or rental cost of construction tools and equipment during time of use on extra work.
   d) Power and consumable supplies for operation of power equipment.
   e) Workmen's Compensation Insurance, Contractor's Public Liability and Property Damage Insurance, and Comprehensive Automobile Liability Insurance.
   f) Social Security and old age and unemployment contributions.
   g) Add to cost under (2), fixed fee to be agreed upon, but not to exceed fifteen percent (15%) of actual cost of work performed with their own labor force. Fee shall be compensation to cover cost of supervision, overhead, bond, profit and any other general expense.
   h) On that portion of the Work under (2) done under subcontract, Contractor may include not over seven and one-half percent (7½%) for supervision, overhead, bond, profit and any other general expense.
   i) Department may require correct amount of costs with supporting vouchers; Contractor shall keep and present in such form as directed.
3. Cost-plus work, with not-to-exceed dollar limit, based on actual cost of:
   a) Labor, including foremen, and all fringe benefits that are associated with their wages.
   b) Materials entering permanently into the Work.
   c) Ownership or rental cost of construction tools and equipment during time of use on extra work. Rental cost cannot exceed fifty percent (50%) replacement value of rented equipment.
   d) Power and consumable supplies for operation of power equipment.
   e) Workmen's Compensation Insurance, Contractor's Public Liability and Property Damage Insurance, and Comprehensive Automobile Liability Insurance.
   f) Social Security and old age and unemployment contributions.
   g) To cost under (3), there shall be added fixed fee to be agreed upon but not to exceed fifteen percent (15%) of actual cost of work performed with their own labor force. Fee shall be compensation to cover cost of supervision, overhead, bond, profit, and any other general expense.
   h) On that portion of the Work under (3) done under subcontract, Contractor may include not over seven and one-half percent (7½%) for supervision, overhead, bond, profit, and any other general expense.
   i) Contractor shall keep and present, in such form as directed, correct amount of cost together with such supporting vouchers as may be required by Department.

B. If Contractor claims that by any instructions given by Architect / Engineer, Department, by drawings or otherwise, regarding performance of the Work or furnishing of material under Contract, involves extra cost, Contractor shall give Department written notice of cost thereof within two (2) weeks after receipt of such instructions and in any event before proceeding to execute work, unless delay in executing work would endanger life or property.

C. No claim for extra work or cost shall be allowed unless it was done in pursuance of written Change Order from Architect / Engineer and approved by Department, as previously mentioned, and claim presented with payment request submitted after changed or extra work is completed.

D. Negotiation of cost for change in the Work shall not be cause for Contractor to delay prosecution of the Work if Contractor has been authorized in writing by Public Works Project Manager to proceed.

19. EXTRAS

A. Without invalidating Contract, Department may order extra work or make changes by altering, adding to or deducting from the Work, contract sum being adjusted in accordance with Article 18 herein.

20. TIME FOR COMPLETION

A. Contractor agrees that the Work shall be prosecuted regularly and diligently and complete the Work as stated in Construction Documents.

21. CORRECTION OF WORK

A. All work, all materials whether incorporated in the Work or not, and all processes of manufacture shall at all times and places be subject to inspection of Architect / Engineer and Public Works Project Manager who shall be judge of quality and suitability of the Work, materials, and processes of manufacture for purposes for which they are used. Should they fail to meet Architect / Engineer's and Public Works Project Manager's approval they shall be reconstructed, made good, replaced or corrected, by Contractor at Contractor's expense. Immediately remove all rejected material from site.

B. If Contractor defaults or neglects to carry out the Work in accordance with Construction Documents or fails to perform any provision of Contract, Department may, after ten (10) business days' written notice to Contractor and without prejudice to any other remedy County may have, make good such deficiencies. In such case, appropriate Change Order shall be issued deducting from Contractor's payments then or thereafter, cost of correcting such deficiencies, including cost of Architect / Engineer's additional services made necessary by such default, neglect or failure.

22. SUBSURFACE CONDITIONS FOUND DIFFERENT

A. If Contractor encounters subsurface or latent conditions at site materially differing from those shown on Drawings or indicated in Specifications, Contractor shall immediately give notice to Architect / Engineer and Public Works Project Manager of such conditions before they are disturbed. Architect / Engineer will thereupon promptly investigate conditions, and if Architect / Engineer finds that they materially differ from those shown on Drawings or indicated in Specifications, Architect / Engineer will at once make such changes as necessary, any increase or decrease of cost resulting from such changes to be adjusted in manner provided in above Article 18 entitled “Changes in the Work”.

23. RIGHT OF DEPARTMENT TO TERMINATE CONTRACT

A. In event that any provisions of this Contract are violated by Contractor or by any subcontractors, County may serve written notice upon Contractor and Surety of its intention to terminate Contract, such notice to contain reasons for such intention to terminate Contract, and unless within ten (10) business days after serving of such notice upon Contractor, such violation or delay shall cease and satisfactory arrangement or correction be made, Contract shall, upon expiration of said ten (10) business days, cease and terminate.

B. In event of any such termination, County shall immediately serve notice thereof upon Surety and Contractor, and Surety shall have right to take over and perform Contract subject to County’s approval; provided, however, that if Surety does not commence performance thereof within ten (10) business days from date of mailing to such Surety of notice of termination, County may take over the Work and prosecute same to completion by contract, or by force account, at expense of Contractor; Contractor and Surety shall be liable to County for any excess cost occasioned County thereby, and in such event County may take possession of and utilize in completing the Work, such materials and equipment as may be on the Work site and therefore necessary.

24. CONSTRUCTION SCHEDULE AND PERIODIC ESTIMATES

A. Contractor shall be responsible for Construction Schedule and coordination. Immediately after execution and delivery of Contract and before making first payment, Contractor shall notify all subcontractors to furnish all required information to develop Construction Schedule. Contractor and all subcontractors associated with the Work shall furnish following information from each Division of Specifications:
   1. List of construction activities;
   2. Start, finish and time required for completion of each activity;
   3. Sequential relationships between activities;
   4. Identify all long lead-time items, key events, meetings or activities such as required submittals, fabrication and delivery, procurement of materials, installation and testing;
   5. Weekly definition of extent of work and areas of activity for each trade or Subcontract; and
   6. Other information as determined by Public Works Project Manager.

B. In addition to above requested items, Contractor shall request delivery dates for all County-furnished equipment, materials or labor. This shall include any work handled by Department under separate contracts such as asbestos abatement, air and water balancing, etc. Indicate on Construction Schedule these associated delivery and installation dates.

C. Progress Reporting:
   1. Contractor shall update and publish Construction Schedule on monthly basis. Revisions to Schedule shall be by Contractor and made in same detail as original Schedule and accompanied by explanation of reasons for revision; and shall be subject to approval by Department.
   2. Failure of Contractor to keep Schedule in updated format shall result in County hiring firm specializing in construction schedule development and deducting those costs associated with updating process from payments due Contractor.
   3. Contractor shall submit show actual percentage of each activity completed, estimated future progress, and anticipated completion time.

D. Responsibility for timely completion requires:
   1. Contractor and subcontractors understand that performance of each is interdependent upon performance of others.
   2. Whenever it becomes apparent from current schedule, that phasing or progress completion dates will not be met, Contractor must take some or all following actions at no additional cost to County:
      a) Increase construction labor in such quantities and crafts as will eliminate backlog of work.
      b) Increase number of working hours per shift, shifts per working day, working days per week, amount of construction equipment, or any combination of foregoing to eliminate backlog of work.
      c) Reschedule work (yet remain in conformance with Drawings and Specifications).
   3. Prior to proceeding with any of above actions, Contractor shall notify Public Works Project Manager.

E. Maintain current Construction Schedule at all times. Revise Construction Schedule in same detail as original and accompany with explanation of reasons for revision. Schedule shall be subject to approval by Architect / Engineer and Public Works Project Manager.

25. PAYMENTS TO CONTRACTOR

A. Contractor shall provide:
   1. Detailed estimate giving complete breakdown of contract price by Specification Division; and
   2. Periodic itemized estimates of work done for purpose of making partial payments thereon.

B. Submit these estimates for approval first to Architect / Engineer, then to Public Works Project Manager. Costs employed in making up any of these schedules are for determining basis of partial payments and not considered as fixing basis for additions to or deductions from Contract price.

C. County will make partial payments to Contractor for value, proportionate to amount of Contract, of all labor and material incorporated in the Work during preceding calendar month upon receipt of Application and Certificate for Payment form from Architect / Engineer and approval of Department.

D. Contractor shall submit for approval first to Architect / Engineer, and then to Public Works Project Manager all Application and Certificate for Payment forms. If requested, Application and Certificate for Payment shall be supported by such additional evidence as may be required, showing Contractor’s right to payment claimed.

E. Application and Certificate for Payment for preparatory work and materials delivered and suitably stored at site to be incorporated into the Work at some future period, will be given due consideration. Requesting payment for materials stored off site, may be rejected, however, if deemed essential for reasons of job progress, protection, or other sufficient cause, requests will be considered, conditional upon submission by Contractor of bills of sale, photographs and such other procedures as will adequately protect County’s interest such as storage in bonded warehouse with adequate coverage. If there is any error in payment, Contractor is obligated to notify Department immediately, but no longer than ten (10) business days from receipt of payment.

F. Payments by County will be due within forty-five (45) business days after receipt by Department of Application and Certificate for Payment.

G. County will retain five percent (5%) of each Application and Certificate for Payment until final completion and acceptance of all the Work covered by Contract. However, anytime after fifty percent (50%) of the Work has been furnished and installed at site, County will make remaining payments in full if Architect / Engineer and Public Works Project Manager find that progress of the Work corresponds with Construction Schedule. If Architect / Engineer and Public Works Project Manager find that progress of the Work does not correspond with Construction Schedule, County may retain up to ten percent (10%) of each Application and Certificate for Payment for the Work completed.

H. All material and work covered by partial payments made shall become sole property of County, but this provision shall not be construed as relieving Contractor from sole responsibility for care and protection of materials and work upon which payments have been made, or restoration of any damaged work, or as waiver of right of County to require fulfillment of all of terms of Contract.

I. County will make final payment within sixty (60) calendar days after final completion of the Work, and will constitute acceptance thereof. Submit Equal Benefits Compliance Payment Certification with final pay request. Payment may be denied if Certification is not included.

J. County may make payment in full, including retained percentages and less authorized deductions, upon completion and acceptance of each Division where price is stated separately in Contract.

K. Every contractor engaged in performance of any contract for Department of Public Works, Highway & Transportation shall submit to this Department, as requested and with final application for payment for work under said contract, affidavit(s) as required to prove that all debts and claims against this Work are paid in full or otherwise satisfied, and give final evidence of release of all liens against the Work and County. Use “Dane County, Wisconsin Contractor Wage Affidavit” form included in Supplementary Conditions.

26. WITHHOLDING OF PAYMENTS

A. County, after having served written notice on said Contractor, may either pay directly any unpaid bills of which Department has written notice, or withhold from Contractor’s unpaid compensation sum of money deemed reasonably sufficient to pay any and all such lawful claims until satisfactory evidence is furnished that all liabilities have been fully discharged; whereupon, payment to Contractor shall be resumed in accordance with terms of this Contract, but in no event shall these provisions be construed to impose any obligations upon County to either Contractor or Contractor’s Surety.

B. In paying any unpaid bills of Contractor, County shall be deemed agent of Contractor, and any payment so made by County, shall be considered as payment made under Contract by County to Contractor and County shall not be liable to Contractor for any such payment made in good faith.

C. Contractor shall indemnify, hold harmless and defend Dane County, its boards, commissions, agencies, officers, employees and representatives from all claims growing out of lawful demands of subcontractors, laborers, workers, mechanics, material men, and furnishers of machinery and parts thereof, equipment, power tools, and all supplies, including commissary, incurred in performance of this Contract.

D. At Department's request, Contractor shall furnish satisfactory evidence that all obligations of nature designated above have been paid, discharged or waived.

27. ACCEPTANCE OF FINAL PAYMENT AS RELEASE

A. Making of final payment shall constitute waiver of all claims by County except those arising from:
   1. Unsettled lien;
   2. Faulty or defective work appearing after substantial completion;
   3. Failure of the Work to comply with requirements of Construction Documents; or
   4. Terms of any special guarantees required by Construction Documents.

B. Acceptance of final payment shall constitute waiver of all claims by Contractor.

28. PAYMENTS BY CONTRACTOR

A. Contractor shall pay following not later than fifth (5^{th}) business day following each payment received from County:
   1. All transportation and utility services rendered;
   2. All materials, tools, and other expendable equipment that have been delivered at site of the Work to extent of ninety percent (90%) of cost thereof, and balance of cost thereof when said balance is paid to Contractor; and
   3. Each subcontractor, respective amount allowed Contractor because of work performed by subcontractor to extent of subcontractor's interest therein.

29. CONTRACT SECURITY

A. Contractor shall furnish Performance and Payment Bonds in amount at least equal to one hundred percent (100%) of Contract price as security for faithful performance of this Contract and payment of all persons performing labor on project under this Contract and furnishing materials in connection with this Contract.

B. Sample Performance and Payment Bonds that Contractor will be required to execute is bound into these Construction Documents. Before construction Contract is consummated, completed Performance and Payment Bonds must be approved by Department.

30. ASSIGNMENTS

A. Contractor shall not assign whole or any part of this Contract or any moneys due or to become due hereunder without written consent of Department. In case Contractor assigns all or any part of any moneys due or to become due under this Contract, instrument of assignment shall contain clause substantially to effect that it is agreed that right of assignee in and to any moneys due or to become due to Contractor shall be subject to prior claims of all persons, firms and corporations for services rendered or materials supplied for performance of the Work called for in this Contract.

31. MUTUAL RESPONSIBILITY OF CONTRACTORS

A. If, through acts of neglect on part of Contractor or any subcontractor shall suffer loss or damage on the Work, Contractor agrees to settle with such subcontractor by agreement or arbitration if such other subcontractor will so settle. If such subcontractor shall assert any claim against County on account of any damage alleged to have been sustained, Department shall notify Contractor, who shall indemnify, hold harmless and defend Dane County, its boards, commissions, agencies, officers, employees and representatives against any such claim.

32. SEPARATE CONTRACTS

A. Department may award other contracts for the Work and all Contractors shall fully cooperate with each other and carefully adjust their work to that provided under other contracts as may be directed by Department. No Contractor shall commit or permit any act that will interfere with performance of the Work by any other Contractor.

B. Contractor shall coordinate the Work with those of other Contractors. Cooperation will be required in arrangement for storage of materials and in detailed execution of the Work. Contractor, including subcontractors, shall keep informed of progress and detail work of others and shall notify Architect / Engineer or Department immediately of lack of progress or defective workmanship on part of others. Failure of Contractor to keep informed of the Work progressing on site and failure to give notice of lack of progress or defective workmanship by others shall be construed as acceptance by Contractor of status of the Work as being satisfactory for proper coordination with Contractor's own work.

33. SUBCONTRACTS

A. Contractor may use services of specialty subcontractors on those parts of the Work that, under normal contracting practices, are performed by specialty subcontractors.

B. Contractor shall not award any work to any subcontractor without prior approval of Department. Qualifications of subcontractors shall be same as qualifications of Contractor. Request for subcontractor approval shall be submitted to Department fifteen (15) business days before start of subcontractor's work. If subcontractors are changed or added, Contractor shall notify Department in writing.

C. Contractor shall be as fully responsible to County for acts and omissions of subcontractors, and of persons either directly or indirectly employed by them, as Contractor is for acts and omissions of persons directly employed by Contractor.

D. Contractor shall cause appropriate provisions to be inserted in all subcontracts relative to the Work to bind subcontractors to Contractor by terms of General Conditions of Contract and other Construction Documents insofar as applicable to work of subcontractors and to give Contractor same power as regards terminating any subcontract that Department may exercise over Contractor under any provision of Construction Documents.

E. Nothing contained in this Contract shall create any contractual relation between any subcontractor and County.

F. Contractor shall insert in all subcontracts, Articles 26, 33, 43 and 45, respectively entitled: "Withholding of Payments", "Subcontracts", "Affirmative Action Provision and Minority /

Women / Disadvantaged Business Enterprises", and "Minimum Wages", and shall further require all subcontractors to incorporate physically these same Articles in all subcontracts.

34. PUBLIC WORKS PROJECT MANAGER'S AUTHORITY

A. Public Works Project Manager shall:
   1. Administer and ensure compliance with Construction Documents;
   2. Provide responsible on-site observations of construction and have authority to request work and to stop work whenever necessary to insure proper enforcement of Construction Documents;
   3. Convene and chair project meetings and foreman's coordination meetings when necessary to coordinate resolution of conflicts between Contractors, Architects, Engineers, Consultants, and Department; and
   4. Check and inspect material, equipment and installation procedures of all trades for proper workmanship and for compliance with Drawings, Specifications and Shop Drawings, permit no material on project site that is not satisfactory and reject work not in compliance with Construction Documents.

35. ARCHITECT / ENGINEER'S AUTHORITY

A. Architect / Engineer is retained by, and is responsible to Department acting for County.

B. Architect / Engineer shall determine amount, quality, acceptability, and fitness of several kinds of work and materials that are provided under this Contract and shall decide all questions that may arise in relation to said work and construction thereof.

C. Architect / Engineer shall decide meaning and intent of any portion of Specifications and of any Drawings where they may be found obscure or be in dispute.

D. Architect / Engineer shall provide responsible observation of construction. Architect / Engineer has authority to stop the Work whenever such stoppage may be necessary to insure proper execution of Construction Documents.

E. Architect / Engineer shall be interpreter of conditions of Construction Documents and judge of its performance.

F. Within reasonable time, Architect / Engineer shall make decisions on all matters relating to progress of the Work or interpretation of Construction Documents.

G. Architect / Engineer's decisions are subject to review by Public Works Project Manager.

36. STATED ALLOWANCES

A. Stated allowances enumerated in Instructions to Bidders shall cover net cost of materials or equipment, and all applicable taxes. Contractor's cost of delivery and unloading at site, handling costs on site, labor, installation costs, overhead, profit and any other incidental costs shall be included in Contractor's bid, but not as part of cash allowance.

B. Department will solicit at least two (2) bids on materials or equipment for which allowance is stated and select on basis of lowest qualified responsible bid. Contractor will then be instructed to purchase "Allowed Materials". If actual price for purchasing "Allowed Materials", including taxes, is more or less than "Cash Allowance", Contract price shall be adjusted accordingly. Adjustment in Contract price shall not contain any cost items excluded from cash allowance.

37. ESTIMATES OF QUANTITIES

A. Whenever estimated quantities of work to be done and materials to be furnished under this Contract are shown in any of Construction Documents, they are given for use in comparing bids and right is especially reserved to increase or diminish them as they may be deemed reasonably necessary or desirable by Department to complete the Work included in this Contract, and cost for such increase or diminution shall be adjusted in manner provided for in General Conditions of Contract Article 18 entitled "Changes in the Work".

38. LANDS AND RIGHTS-OF-WAY

A. Prior to start of construction, County shall furnish all land and rights-of-way necessary for carrying out and completion of the Work to be performed under this Contract.

39. GENERAL GUARANTEE

A. Neither final certificate of payment nor any provision in Construction Documents nor partial or entire occupancy of premises by County shall constitute acceptance of work not done in accordance with Construction Documents or relieve Contractor of liability in respect to any expressed warranties or responsibility for faulty materials or workmanship.
   1. In no event shall making of any payment required by Contract constitute or be construed as waiver by County of any breach of covenants of Contract or waiver of any default of Contractor and making of any such payment by County while any such default or breach shall exist shall in no way impair or prejudice right of County with respect to recovery of damages or other remedy as result of such breach or default.

B. Contractor shall remedy and make good all defective workmanship and materials and pay for any damage to other work resulting there from, which appear within period of one (1) year from date of substantial completion, providing such defects are not clearly due to abuse or misuse by County. Department will give notice of observed defects with reasonable promptness.

C. Guarantee on work executed after certified date of substantial completion will begin on date when such work is inspected and approved by Architect / Engineer and Public Works Project Manager.

D. Where guarantees or warrantees are required in sections of Specifications for periods in excess of one (1) year, such longer terms shall apply; however, Contractor's Performance and Payment Bonds shall not apply to any guarantee or warranty period in excess of one (1) year.

40. CONFLICTING CONDITIONS

A. Any provision in any of Construction Documents which may be in conflict or inconsistent with any Articles in these General Conditions of Contract or Supplementary Conditions shall be void to extent of such conflict or inconsistency.

B. In case of ambiguity or conflict between Drawings and Specifications, Specifications shall govern.

C. Printed dimensions shall be followed in preference to measurements by scale. Large-scale drawings take precedence over small-scale drawings. Dimensions on Drawings and details are subject to field measurements of adjacent work.

41. NOTICE AND SERVICE THEREOF

A. Any notice to Contractor from Department relative to any part of this Contract shall be in writing and considered delivered and service thereof completed, when said notice is posted, by certified or registered mail, to Contractor at Contractor's last given address, or delivered in person to said Contractor, or Contractor's authorized representative on the Work.

42. PROTECTION OF LIVES AND HEALTH

A. In order to protect lives and health of Contractor's employees under Contract, Contractor shall comply with all pertinent provisions of Wisconsin Administrative Code, Rules of Department of Commerce, relating to Safety and Health.

B. Contractor alone shall be responsible for safety, efficiency and adequacy of Contractor's tools, equipment and methods, and for any damage that may result from their failure or their improper construction, maintenance or operation.

43. AFFIRMATIVE ACTION PROVISION AND MINORITY / WOMEN / DISADVANTAGED BUSINESS ENTERPRISES

A. Affirmative Action Provisions.
   1. During term of their Contract, Contractor agrees not to discriminate on basis of race, religion, color, sex, handicap, age, sexual preference, marital status, physical appearance, or national origin against any person, whether recipient of services (actual or potential), employee, or applicant for employment. Such equal opportunity shall include but not be limited to following: employment, upgrading, demotion, transfer, recruitment, advertising, layoff, termination, training, rates of pay, and any other form of compensation or level of service(s). Contractor agrees to post in conspicuous places, these affirmative action standards so as to be visible to all employees, service recipients and applicants for this paragraph. Listing of prohibited bases for discrimination shall no be construed to amend in any fashion state or federal law setting forth additional bases and exceptions shall be permitted only to extent allowable in state or federal law.
   2. Contractor is subject to this Article only if Contractor has ten (10) or more employees and receives $10,000.00 or more in annual aggregate contracts with County. Contractor shall file and Affirmative Action Plan with Dane County Contract Compliance Officer in accord with Chapter 19 of Dane County Code of Ordinances. Such plan must be filed within fifteen (15) business days of effective date of this Contract and failure to do so by said date shall constitute ground for immediate termination of Contract by County. Contractor shall also, during term of this Contract, provide copies of all announcements of employment opportunities to County's Contract Compliance Office, and shall report annually number of persons, by race, sex and handicap status, who apply for employment, and, similarly classified, number hired and number rejected.
   3. Contact Dane County Contract Compliance Officer at Dane County Contract Compliance Office, 210 Martin Luther King, Jr. Blvd., Room 421, Madison, WI 53703, 608/266-4114.
   4. In all solicitations for employment placed on Contractor's behalf during term of this Contract, Contractor shall include statement to affect Contractor is "Equal Opportunity Employer". Contractor agrees to furnish all information and reports required by

County’s Contract Compliance Officer as same relate to affirmative action and nondiscrimination, which may include any books, records, or accounts deemed appropriate to determine compliance with Chapter 19, Dane County Code of Ordinances, and provision of this Contract.

B. Minority / Women / Disadvantaged / Emerging Small Business Enterprises.
   1. Chapter 19.508 of Dane County Code of Ordinances is official policy of Dane County regarding utilization of, to fullest extent of, Minority Business Enterprises (MBEs), Women Business Enterprises (WBEs) Disadvantage Business Enterprises (DBEs) and Emerging Small Business Enterprises (ESBEs).
   2. Contractor may utilize MBEs / WBEs / DBEs / ESBEs as subcontractors or suppliers. List of subcontractors will be required of low bidder as stated in this Contract. List shall indicate which are MBEs / WBEs / DBEs / ESBEs and percentage of subcontract awarded, shown as percentage of total dollar amount of bid.

44. COMPLIANCE WITH FAIR LABOR STANDARDS

A. During term of this Contract, Contractor shall report to County Contract Compliance Officer, within ten (10) business days, any allegations to, or findings by National Labor Relations Board (NLRB) or Wisconsin Employment Relations Commission (WERC) that Contractor has violated statute or regulation regarding labor standards or relations. If investigation by Contract Compliance Officer results in final determination that matter adversely affects Contractor’s responsibilities under this Contract, and which recommends termination, suspension or cancellation of this Contract, County may take such action.

B. Contractor may appeal any adverse finding by Contract Compliance Officer as set forth in Dane County Ordinance 25.015(11)(c) through (e).

C. Contractor shall post this statement in prominent place visible to employees: “As condition of receiving and maintaining contract with Dane County, this employer shall comply with federal, state and all other applicable laws prohibiting retaliation or union organizing.”

45. DOMESTIC PARTNERSHIP BENEFITS

A. Contractor agrees to provide same economic benefits to all of its employees with domestic partners as it does to employees with spouses, or cash equivalent if such benefit cannot reasonably be provided. Contractor agrees to make available for County inspection Contractor’s payroll records relating to employees providing services on or under this Contract or subcontract. If any payroll records of Contractor contain any false, misleading or fraudulent information, or if Contractor fails to comply with provisions of Chapter 25.13, Dane County Ordinances, contract compliance officer may withhold payments on Contract; terminate, cancel or suspend Contract in whole or in part; or, after due process hearing, deny Contractor right to participate in bidding on future County contracts for period of one year after first violation is found and for period of three years after second or subsequent violation is found.

46. USE AND OCCUPANCY PRIOR TO ACCEPTANCE

A. Contractor agrees to use and occupancy of portion or unit of the Work before formal acceptance by Department, provided Department:

1. Secures written consent of Contractor; except when in opinion of Public Works Project Manager, Contractor is chargeable with unwarranted delay in final cleanup of punch list items or other Contract requirements.
2. Secures endorsement from insurance carrier and consent of Surety permitting occupancy of building or use of the Work during remaining period of construction, or, secures consent of Surety.
3. Assumes all costs and maintenance of heat, electricity and water.
4. Accepts all work completed within that portion or unit of the Work to be occupied, at time of occupancy.

47. MINIMUM WAGES

A. Contractor shall post, at appropriate conspicuous point on site of project, schedule showing all determined minimum wage rates for various classes of laborers and mechanics to be engaged in the Work under this Contract and all deductions, if any, required by law to be made from unpaid wages actually earned by laborers and mechanics so engaged.

B. Supplementary Conditions section in Construction Documents lists wage determinations required by State Law.

C. If, after award of Contract, it becomes necessary to employ any person in trade or occupation not classified in wage determinations, such person shall be paid at not less than such rate as shall be determined by Wisconsin Department of Workforce Development. Such approved minimum rate shall be retroactive to time of initial employment of such person in such trade or occupation. Contractor shall notify Department of Contractor’s intention to employ persons in trades or occupations not so classified in sufficient time for Department to obtain approved rates for such trades or occupations.

D. Specified wage rates are minimum rates only, and Department will not consider any claims for additional compensation made by Contractor because of payment by Contractor of any wage rate in excess of applicable rate contained in this Contract. Contractor shall adjust any disputes in regard to payment of wages in excess of those specified in this Contract.

E. Submit required affidavit(s) to Department of Public Works, Highway & Transportation, as requested and with final application for payment for work under said contract. Affidavit(s) shall clearly indicate name, trade or occupation, and paid wages of every laborer, worker or mechanic employed by Contractor and all subcontractors during billing period including accurate record of number of hours worked by each employee and actual wages paid as stipulated in Wisconsin Statue 66.0903. Use “Dane County, Wisconsin Contractor Wage Affidavit” form included in Supplementary Conditions.

48. CLAIMS

A. No claim may be made until Department’s Assistant Public Works Director has reviewed Architect / Engineer’s decision as provided for in Article 35 of General Conditions of Contract. If any claim remains unresolved after such review by Department's Assistant Public Works Director the claim may be filed under Wisconsin Statute 893.80. Work shall progress during period of any dispute or claim. Unless specifically agreed between parties, venue will be in Dane County, Wisconsin.

49. ANTITRUST AGREEMENT

A. Contractor and County recognize that in actual economic practice, overcharges resulting from antitrust violations are in fact usually borne by County. Therefore, Contractor hereby assigns to County any and all claims for such overcharges as to goods and materials purchased in connection with this Contract, except as to overcharges which result from antitrust violations commencing after price is established under this Contract and any change order thereto.

50. INSURANCE

A. Contractor Carried Insurance:
   1. Contractor shall not commence work under this Contract until Contractor has obtained all insurance required under this Article and has provided evidence of such insurance to Risk Manager, 425 City-County Building, 210 Martin Luther King Jr. Blvd., Madison, WI 53703. Contractor shall not allow any subcontractor to commence work until insurance required of subcontractor has been so obtained and approved. Company providing insurance must be licensed to do business in Wisconsin.
   2. Worker's Compensation Insurance:
      a) Contractor shall procure and shall maintain during life of this Contract, Worker's Compensation Insurance as required by statute for all of Contractor's employees engaged in work at site of project under this Contract and, in case of any such work sublet, Contractor shall require subcontractor similarly to provide Worker's Compensation Insurance for all of latter's employees to be engaged in such work unless such employees are covered by protection afforded by Contractor's Worker's Compensation Insurance.
      b) If any claim of employees engaged in hazardous work on project under this Contract is not protected under Worker's Compensation Statute, Contractor shall provide and shall cause each subcontractor to provide adequate Employer's Liability Insurance for protection of such of Contractor's employees as are not otherwise protected.
   3. Contractor's Public Liability and Property Damage Insurance:
      a) Contractor shall procure and maintain during life of this Contract, Contractor's Public Liability Insurance and Contractor's Property Damage Insurance in amount not less than $1,000,000 bodily injury, including accidental death, to any one person, and subject to same limit for each person, in amount not less than $1,000,000 on account of one accident, and Contractor's Property Damage Insurance in amount not less then $1,000,000 or combined single limit of at least $1,000,000 with excess coverage over and above general liability in amount not less than $5,000,000. Contractor shall add "Dane County" as additional insured for each project.
      b) Contractor's Public Liability and Property Damage Insurance shall include Products, Completed Operation, and Contractual Liability under Insurance Contract. "Contractor shall in all instances save, defend, indemnify and hold harmless County and Architect / Engineer against all claims, demands, liabilities, damages or any other costs which may accrue in prosecution of the Work and that Contractor will save, defend, indemnify and hold harmless County and Architect / Engineer from all damages caused by or as result of Contractor's operations" and each shall be listed as additional insured on Contractor's and sub-contractors' insurance policies.
      c) Obligations of Contractor under Article 50.A.2.b) shall not extend to liability of Architect / Engineer, agents or employees thereof, arising out of:
         1) Preparation or approval of maps, drawings, opinions, reports, surveys, change orders, designs or specifications; or
         2) Giving of or failure to give directions or instructions by Architect / Engineer, agents or employees thereof provided such giving or failure to give is primary cause of injury or damage.

d) Contractor shall procure and shall maintain during life of this Contract, Comprehensive Automobile Liability Insurance covering owned, non-owned and hired automobiles for limits of not less than $1,000,000 each accident single limit, bodily injury and property damage combined with excess coverage over and above general liability in amount not less than $5,000,000.
e) Contractor shall either:
    1) Require each subcontractor to procure and to maintain during life of subcontract, subcontractor's Public Liability Property Damage Insurance, and Comprehensive Automobile Liability Insurance of type and in same amount specified in preceding paragraphs; or
    2) Insure activities of subcontractors in Contractor's own policy.

4. Scope of Insurance and Special Hazards: Insurance required under Article 50.A.2 & 50.A.3. hereof shall provide adequate protection for Contractor and subcontractors, respectively, against damage claims which may arise from operations under this Contract, whether such operation be by insured or by anyone directly or indirectly employed by insured and also against any of special hazards which may be encountered in performance of this Contract as enumerated in Supplementary Conditions.
5. Proof of Carriage of Insurance: Contractor shall furnish Risk Manager with certificates showing type, amount, class of operations covered, effective dates, dates of expiration of policies and "Dane County" listed as additional insured. Such certificates shall also contain (substantially) following statement: "Insurance covered by this certificate will not be canceled or materially altered, except after ten (10) business days written notice has been received by Risk Manager."

B. Builder's Risk:
1. County shall provide Builder's Risk insurance coverage for its insurable interests in construction or renovation projects with completed value of $1,000,000 or less. Therefore, if project completed value is more than $1,000,000, Contractor shall obtain and maintain in force, at its own expense, Builder's Risk Insurance on all risks for amount equal to full completed value of covered structure or replacement value of alterations or additions. Any deductible shall not exceed $25,000 for each loss. Policy shall include occupancy clause and list Dane County as loss payee.

C. Indemnification / Hold Harmless:
1. Contractor shall indemnify, hold harmless and defend Dane County, its boards, commissions, agencies, officers, employees and representatives from and against all claims, damages, losses and expenses including attorneys' fees arising out of or resulting from performance of the Work, provided that any such claim, damage, loss or expense is attributable to bodily injury, sickness, disease or death, or to injury to or destruction of tangible property (other than the Work itself) including loss of use resulting therefrom, and is caused in whole or in part by any act or omission of Contractor, any subcontractor, anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable, regardless of whether or not it is caused in part by part indemnified hereunder.
2. In any and all claims against Dane County, its boards, commissions, agencies, officers, employees and representatives or by any employee of Contractor, any subcontractor, anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable, indemnification obligation under this Contract shall not be limited in any way by any limitation on amount or type of damages, compensation or benefits payable by or for Contractor or any subcontractor under worker's compensation acts, disability benefits or other employee benefit acts.
3. Obligations of Contractor under this Contract shall not extend to liability of Architect / Engineer, its agents or employees arising out of:

a) Preparation or approval of maps, drawings, opinion, reports, surveys, change orders, designs or specifications; or
b) Giving of or failure to give directions or instruction by Architect / Engineer, its agents or employees provided such giving or failure to give is primary cause of injury or damage.

4. Dane County shall not be liable to Contractor for damages or delays resulting from work by third parties or by injunctions or other restraining orders obtained by third parties.

51. WISCONSIN LAW CONTROLLING

A. It is expressly understood and agreed to by parties hereto that in event of any disagreement or controversy between parties, Wisconsin law shall be controlling.

SUPPLEMENTARY CONDITIONS

1. APPLICATION & CERTIFICATE FOR PAYMENT

A. Every contractor engaged in performance of any contract for Department of Public Works, Highway & Transportation shall submit partial and final Application & Certificate for Payment for work under said contract. Form shall provide similar information as shown on AIA G702™ and G703™ forms (samples shown below). Forms shall be submitted to [project Architect / Engineer, Public Works Project Manager] for approval.

AIA® Document G702™ – 1992

Application and Certificate for Payment

TO OWNER:	PROJECT:	APPLICATION NO:	Distribution to:
		PERIOD TO:	OWNER ☐
		CONTRACT FOR:	ARCHITECT ☐
FROM CONTRACTOR:	VIA ARCHITECT:	CONTRACT DATE:	CONTRACTOR ☐
		PROJECT NOS: / /	FIELD ☐
			OTHER ☐

CONTRACTOR'S APPLICATION FOR PAYMENT

Application is made for payment, as shown below, in connection with the Contract. AIA Document G703™, Continuation Sheet, is attached.

1. ORIGINAL CONTRACT SUM .... $________
2. NET CHANGE BY CHANGE ORDERS .... $________
3. CONTRACT SUM TO DATE *(Line 1 ± 2)* .... $________
4. TOTAL COMPLETED & STORED TO DATE *(Column G on G703)* ...... $________
5. RETAINAGE:
   a. _____% of Completed Work *(Columns D + E on G703)* $________
   b. _____% of Stored Material *(Column F on G703)* $________

   Total Retainage *(Lines 5a + 5b, or Total in Column I of G703)* ...... $________
6. TOTAL EARNED LESS RETAINAGE .... $________
   (Line 4 minus Line 5 Total)
7. LESS PREVIOUS CERTIFICATES FOR PAYMENT .... $________
   (Line 6 from prior Certificate)
8. CURRENT PAYMENT DUE .... $
9. BALANCE TO FINISH, INCLUDING RETAINAGE
   (Line 3 minus Line 6) $________

CHANGE ORDER SUMMARY	ADDITIONS	DEDUCTIONS
Total changes approved in previous months by Owner	$	$
Total approved this month	$	$
TOTAL	$	$
NET CHANGES by Change Order	$	

The undersigned Contractor certifies that to the best of the Contractor's knowledge, information and belief the Work covered by this Application for Payment has been completed in accordance with the Contract Documents, that all amounts have been paid by the Contractor for Work for which previous Certificates for Payment were issued and payments received from the Owner, and that current payment shown herein is now due.

CONTRACTOR:

By: ____________ Date: ________

State of:

County of:

Subscribed and sworn to before me this day of

Notary Public:

My commission expires:

ARCHITECT'S CERTIFICATE FOR PAYMENT

In accordance with the Contract Documents, based on on-site observations and the data comprising this application, the Architect certifies to the Owner that to the best of the Architect's knowledge, information and belief the Work has progressed as indicated, the quality of the Work is in accordance with the Contract Documents, and the Contractor is entitled to payment of the AMOUNT CERTIFIED.

AMOUNT CERTIFIED .... $________

(Attach explanation if amount certified differs from the amount applied. Initial all figures on this Application and on the Continuation Sheet that are changed to conform with the amount certified.)

ARCHITECT:

By: ____________ Date: ________

This Certificate is not negotiable. The AMOUNT CERTIFIED is payable only to the Contractor named herein. Issuance, payment and acceptance of payment are without prejudice to any rights of the Owner or Contractor under this Contract.

AIA® Document G703™ – 1992

Continuation Sheet

AIA Document G702™–1992, Application and Certificate for Payment, or G732™–2009, Application and Certificate for Payment, Construction Manager as Adviser Edition, containing Contractor's signed certification is attached.
In tabulations below, amounts are in US dollars.
Use Column I on Contracts where variable retainage for line items may apply.

APPLICATION NO:
APPLICATION DATE:
PERIOD TO:
ARCHITECT'S PROJECT NO:

A	B	C	D	E	F	G		H	I
			WORK COMPLETED						
ITEM NO.	DESCRIPTION OF WORK	SCHEDULED VALUE	FROM PREVIOUS APPLICATION (D + E)	THIS PERIOD	MATERIALS PRESENTLY STORED (Not in D or E)	TOTAL COMPLETED AND STORED TO DATE (D+E+F)	% (G ÷ C)	BALANCE TO FINISH (C – G)	RETAINAGE (If variable rate)
	GRAND TOTAL								

CAUTION: You should sign an original AIA Contract Document, on which this text appears in RED. An original assures that changes will not be obscured.

2. CONTRACTOR WAGE AFFIDAVIT

A. Every contractor engaged in performance of any contract for Department of Public Works, Highway & Transportation shall submit to this Department, as requested and with final application for payment for work under said contract, affidavit in form as hereinafter set forth in this section. Affidavit affirms that all persons employed by contractor or by any of contractor's subcontractors on such contract have been paid no less than minimum wages established under Dane County Ordinances, Chapter 40, Subchapter II (Minimum Wage Ordinance) and in effect at date of execution of contract, that full payment of wages earned has been made, and that no rebates either directly or indirectly have been made. Form of such affidavit is included in this section.

B. Form should be included with a copy of the final contract invoice forwarded to your contract representative at Dane County.

DANE COUNTY, WISCONSIN

CONTRACTOR WAGE AFFIDAVIT

COMPANY NAME: ____

ADDRESS: ____

____

CONTRACT NO.: _____________ DIVISION(S) OF WORK: __________________________

AFFIDAVIT

STATE OF WISCONSIN)
) ss.
DANE COUNTY)

I, ____, being
name and title of person signing affidavit

first duly sworn at ____,
city & state of company incorporation

on oath, depose and say that with respect to the payment of the persons employed by the

____, subcontractors on the ______________
contractor company name division(s) of work

__________________________________, at the _______________________________________
building or site of project

that during the period commencing ____________________, and ending ____________________
date date

all persons employed on said project have been paid the full wages earned, that no rebates have been or will be made either directly or indirectly by said contractor or subcontractor from the full weekly wages earned by any person, and that no deductions have been made either directly or indirectly from the full weekly wages earned by any person, other than authorized legal deductions (including taxes such as Federal Income Withholding and Social Security, State and

____,
state any other legal deductions such as union dues, unemployment insurance, 401k contributions, etc., or fill in "N/A"

and that there is full compliance with the provisions and intent of the requirements of Dane County Ordinances, Chapter 40, Subchapter II (Minimum Wage Ordinance). This affidavit is made to induce Dane County to approve the application for payment to which this affidavit is attached.

____
Contractor Company Name

____ _______________________
Signature Title

Sworn to before me this _____ day of ______________, 20__.

_______________________________________ My Commission expires _________________
Notary Public Date

SECTION 01 00 00

BASIC REQUIREMENTS

PART 1 GENERAL

1.1 SECTION SUMMARY

A. Section Includes:
1. Section Summary
2. Summary of the Work
3. Contractor Use of Premises
4. Applications for Payment
5. Change Procedures
6. Alternates
7. Lump Sum Allowances for Work
8. Coordination
9. Cutting and Patching
10. Conferences
11. Progress Meetings
12. Job Site Administration
13. Submittal Procedures
14. Proposed Products List
15. Shop Drawings
16. Product Data
17. Samples
18. Manufacturers' Instructions
19. Manufacturers' Certificates
20. Quality Assurance / Quality Control of Installation
21. References
22. Interior Enclosures
23. Protection of Installed Work
24. Parking
25. Staging Areas
26. Occupancy During Construction and Conduct of Work
27. Protection
28. Progress Cleaning
29. Products
30. Transportation, Handling, Storage and Protection
31. Product Options
32. Substitutions
33. Starting Systems
34. Demonstration and Instructions
35. Contract Closeout Procedures
36. Final Cleaning
37. Adjusting
38. Operation and Maintenance Data
39. Spare Parts and Maintenance Materials
40. As-Built and Record Drawings and Specifications

1.2 SUMMARY OF THE WORK

A. Project Description: Perform the Work as specified and detailed in Construction Documents package. Contractor to provide all civil site work, building construction, and all associated equipment procurement and installation.

B. Work by Owner: See Section 19 in Instructions to Bidders.

C. Diggers Hotline:
   1. It is General Contractor’s responsibility to contact Diggers Hotline to have all utility locations marked prior to excavation and planning an excavation in a timely manner so as not to delay the Work.
   2. Diggers Hotline shall also be used to obtain information on safe working clearances from overhead lines.
   3. Completely comply with all requirements of each affected utility company.
   4. It is General Contractor’s responsibility to contact & hire private utility locating services if necessary.

1.3 CONTRACTOR USE OF PREMISES

A. Limit use of premises to allow work by others and work by Owner.

B. Coordinate utility outages and shutdowns with Owner.

1.4 APPLICATIONS FOR PAYMENT

A. Submit one (1) original copies with “wet” signatures of each application on AIA G702™ and G703™ forms or approved contractors invoice form.

B. Content and Format: Utilize Schedule of Values for listing items in Application for Payment.

C. Payment Period: Monthly.

D. Submit Applications for Payment to Architect / Engineer for initial approval. Architect / Engineer will forward approved copies to Owner who will also approve & process for payment.

1.5 CHANGE PROCEDURES

A. Outlined in Section 18, “Change in the Work” of General Conditions of Contract.

1.6 ALTERNATES

A. See Bid Form

B. Alternates quoted on Bid Form shall be reviewed and accepted or rejected at Owner's option.

C. Coordinate related work and modify surrounding work as required.

1.7 LUMP SUM ALLOWANCES FOR WORK

A. As outlined in Section 01 22 00 titled “Measurement and Payment”.

1.8 COORDINATION

A. Coordinate scheduling, submittals, and work of various sections of Specifications to assure efficient and orderly sequence of installation of interdependent construction elements.

B. Verify utility requirement characteristics of operating equipment are compatible with building utilities.

C. Coordinate space requirements and installation of mechanical and electrical work that are indicated diagrammatically on Drawings.

D. Contractor shall provide Public Works Project Engineer with work plan that ensures the Work will be completed within required time of completion.

E. Public Works Project Manager may choose to photograph or videotape site or workers as the Work progresses.

1.9 CUTTING AND PATCHING

A. Outlined in Section 5, “Cutting and Patching” of General Conditions of Contract.

1.10 CONFERENCES

A. There will be pre-bid conference for this project; see Instructions to Bidders.

B. Owner will schedule a preconstruction conference after Award of Contract for all affected parties.

C. Contractor shall submit Construction Schedule at pre-construction conference.

D. When required in individual Specification section, convene a pre-installation conference at project site prior to commencing work of Section.

1.11 PROGRESS MEETINGS

A. Owner shall schedule and administer meetings throughout progress of the Work at minimum of two (2) per month.

B. Architect / Engineer shall preside at meetings, record minutes, and distribute copies within two (2) business days to those affected by decisions made.

C. Attendance at progress meetings by General Contractor, subcontractors, or their authorized representative, is mandatory.

D. Contractors shall give verbal reports of progress on the Work, discuss schedule for upcoming period and present all conflicts, discrepancies or other difficulties for resolution.

E. Day & time of progress meetings to be determined at pre-construction meeting.

1.12 JOB SITE ADMINISTRATION

A. Architect / Engineer shall provide construction inspections (two inspections/week – minimum).

1.13 SUBMITTAL PROCEDURES

A. Submittal form to identify Project, Contractor, Subcontractor or supplier; and pertinent Construction Documents references.

B. Apply Contractor's stamp, signed or initialed, certifying that review, verification of Products required, field dimensions, adjacent construction work, and coordination of information is in accordance with requirements of the Work and Construction Documents.

C. Identify variations from Construction Documents and Product or system limitations that may be detrimental to successful performance of completing the Work.

D. Revise and resubmit submittals as required; identify all changes made since previous submittal.

1.14 PROPOSED PRODUCTS LIST

A. Within fifteen (15) business days after date of Award of Contract, submit complete list of major Products proposed for use, with name of manufacturer, trade name, and model number of each Product.

1.15 SHOP DRAWINGS

A. Outlined in Section 4, “Shop Drawings, Product Data and Samples” of General Conditions of Contract.

1.16 PRODUCT DATA

A. Outlined in Section 4, “Shop Drawings, Product Data and Samples” of General Conditions of Contract.

1.17 SAMPLES

A. Outlined in Section 4, “Shop Drawings, Product Data and Samples” of General Conditions of Contract.

1.18 MANUFACTURERS' INSTRUCTIONS

A. When specified in individual Specification sections, submit manufacturers' printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, in quantities specified for Product Data.

1.19 MANUFACTURERS' CERTIFICATES

A. When specified in individual Specification sections, submit manufacturers' certificate to Public Works Project Manager for review, in quantities specified for Product Data.

B. Indicate material or Product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.

1.20 QUALITY ASSURANCE / QUALITY CONTROL OF INSTALLATION

A. Monitor quality control over suppliers, manufacturers, Products, services, site conditions, and workmanship, to produce work of specified quality.

B. Comply fully with manufacturers' instructions.

C. Comply with specified standards as minimum quality for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

1.21 REFERENCES

A. Conform to reference standard by date of issue current as of date for receiving bids.

B. Should specified reference standard conflict with Construction Documents, request clarification from Public Works Project Manager before proceeding.

1.22 INTERIOR ENCLOSURES

A. Not Applicable.

1.23 PROTECTION OF INSTALLED WORK

A. Outlined in Section 15, “Protection of Work and Property” of General Conditions of Contract.

1.24 PARKING

A. Arrange for temporary parking areas to accommodate construction personnel. Parking shall be available at the Work site.

B. All contractors and their employees shall cooperate with General Contractor and others in parking of vehicles to avoid interference with normal operations and construction activities.

C. Do not obstruct existing service drives and parking lots with equipment, materials and / or vehicles. Keep accessible for Owner’s use at all times.

1.25 STAGING AREAS

A. Coordinate staging areas with Public Works Project Manager prior to starting the Work.

B. On-site space for use as staging areas and storage of materials is limited and will be apportioned among various Contractors as their needs dictate with due regard for storage requirements of each Contractor. Each Contractor shall be responsible for safety of equipment and materials that are stored on site.

1.26 OCCUPANCY DURING CONSTRUCTION AND CONDUCT OF WORK

A. Owner shall not be held liable for any lost time, wages, or impacts to construction schedule by any Contractor or construction personnel dismissed for failure to uphold requirements of this Section.

B. Areas of existing facility will be occupied during period when the Work is in progress. Work may be done during normal business hours (8:00 am to 4:30 pm), but confer with Owner, schedule work and store materials so as to interfere as little as possible with normal use of premises. Notify Owner when coring or similar noise making work is to be done and obtain Owner's written approval of schedule. If schedule is not convenient for Owner, reschedule and resubmit new times for Owner approval. Coring of floor along with other noisy work may have to be done on second and third shifts.

C. Areas of existing facility will be occupied during period when the Work is in progress. Work may be done during normal business hours (8:00 am to 4:30 pm), but confer with Owner, schedule work and store materials so as to interfere as little as possible with normal use of premises. Work performed on Saturday shall be by permission of Owner. Notify Owner when coring or similar noise making work is to be done and obtain Owner's written approval of schedule. If schedule is not convenient for Owner, reschedule and resubmit new times for Owner approval. Coring of floor along with other noisy work may have to be done on second and third shifts.

D. Contractor shall provide adequate protection for all parts of facility, its contents and occupants wherever the Work under this Contract is to be performed.

E. Each Contractor shall arrange with Owner to make necessary alterations, do new work, make connections to all utilities, etc., at such times as will not cause interruption of utility services to facility. Contractor doing this work shall protect, cap, cut off and / or replace and relocate existing pipes, electrical work and other active utilities encountered which may interfere with new construction work.

F. New work in extension of existing work shall correspond in all respects with that to which it connects or similar existing work unless otherwise indicated or specified.
   1. Existing work shall be cut, altered, removed or replaced as necessary for performance of Contract obligations.
   2. Work remaining in place, damaged or defaced by reason of work done under this Contract shall be restored equal to its condition at time of Award of Contract.
   3. If removal of work exposes discolored or unfinished surfaces or work out of alignment, such surfaces shall be refinished or materials replaced as necessary to make continuous work uniform and harmonious.

G. Contractor is responsible for providing & maintaining temporary toilet facilities.

1.27 PROTECTION

A. Contractor shall protect from damage / injury all trees, shrubs, hedges, plantings, grass, mechanical, electrical & plumbing equipment, walks and driveways and pay for any damage to same resulting from insufficient or improper protection.

B. Contractor shall provide and maintain barricades & signage to prohibit public access to construction site.

1.28 PROGRESS CLEANING

A. Outlined in Section 6, “Cleaning Up” of General Conditions of Contract.

1.29 PRODUCTS

A. Products: Means new material, machinery, components, equipment, fixtures, and systems forming the Work, but does not include machinery and equipment used for preparation, fabrication, conveying and erection of the Work. Products may also include existing materials or components specifically identified for reuse.

B. Do not use materials and equipment removed from existing premises, except as specifically identified or allowed by Construction Documents.

1.30 TRANSPORTATION, HANDLING, STORAGE AND PROTECTION

A. Transport, handle, store and protect Products in accordance with manufacturer's instructions.

1.31 PRODUCT OPTIONS

A. Where definite material is specified, it is not intentional to discriminate against "equal" product made by another manufacturer. Intention is to set definite standard of material quality. Should bidder choose to bid materials other than those specified, bidder shall submit said materials specifications to Public Works Project Manager for approval at least seven (7) business days prior to Bid Due Date.

B. Products and materials that are not specified, but have been approved for use by Public Works Project Manager shall be identified in addenda to all bidding contractors.

C. Requests for material or product substitutions submitted after Bid Due Date shall not be considered. Owner reserves right to approve or reject substitutions based on Specification requirements and intended use.

1.32 SUBSTITUTIONS

A. Public Works Project Manager shall consider requests for Substitutions only up to seven (7) business days prior to date of Bid Due Date.

B. Document each request with complete data substantiating compliance of proposed Substitution with Construction Documents.

C. Submit three (3) copies of requests for Substitution for consideration. Limit each request to one (1) proposed Substitution.

D. Substitutions shall not change contract price established at Bid Due Date.

1.33 STARTING SYSTEMS

A. Provide written notification prior to start-up of each equipment item or system.

B. Ensure that each piece of equipment or system is ready for operation.

C. Execute start-up under supervision of responsible persons in accordance with manufacturers' instructions.

D. Submit written report that equipment or system has been properly installed and is functioning correctly.

1.34 DEMONSTRATION AND INSTRUCTIONS

A. Demonstrate operation and maintenance of Products to Owner's personnel prior to date of final inspection.

B. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at agreed-upon times, at designated location.

C. Owner may choose to photograph or videotape demonstration session; demonstration and demonstrator shall be to level of satisfaction of Owner.

1.35 CONTRACT CLOSEOUT PROCEDURES

A. Submit final Application for Payment identifying total adjusted Contract Sum / Price, previous payments, and amount remaining due.

1.36 FINAL CLEANING

A. Outlined in Section 6, “Cleaning Up” of General Conditions of Contract.

1.37 ADJUSTING

A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

1.38 OPERATION AND MAINTENANCE MANUAL

A. Provide two (2) bound, hard-copy operation and maintenance manuals that include all systems, materials, products, equipment, mechanical and electrical equipment and systems supplied and installed in the Work. Provide electronic version of operation and maintenance manual also.

1.39 SPARE PARTS AND MAINTENANCE MATERIALS

A. Provide Products, spare parts, maintenance and extra materials in quantities specified in individual Specification Sections.

B. Deliver to the Work site and place in location as directed.

1.40 AS-BUILT AND RECORD DRAWINGS AND SPECIFICATIONS

A. Contractor shall furnish with original marked up redlines of Construction Documents' drawings and specifications that shall include all Addendums, Change Orders, Construction Bulletins, on-site changes, field corrections, etc. These are project As-Built Drawings & Specifications.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01 11 00

SUMMARY OF WORK

PART 1 - GENERAL

1.1 Section Includes

A. Project Description

B. Work Covered by Contract Documents

C. Related Work Performed by OWNER or Under Separate Contract.

D. Commencement of the Work

E. Project Schedule and Hours of Work

F. Work Sequence.

G. Communications during Construction

H. CONTRACTOR Use of Premises.

I. Site Health and Safety Issues

J. Quality Assurance / Coordination

K. Warranties

L. Defect Assessment

M. Project Meetings

N. Submittals

O. Schedule of Values

P. Measurement and Payment

Q. Application for Payment

R. Union Issues

1.2 Project Description

A. Construction of a Renewable Natural Gas (RNG) facility that integrates with a Biogas Cleaning Facility (by others). In addition to all connections to the Biogas Cleaning Facility, major components to be constructed are a landfill gas (LFG) blower and flare facility, RNG trailer offload facility, metering facility, gas pipeline and a maintenance building. Work includes but is not necessarily limited to site preparation, stormwater management, excavation and grading, concrete foundation and concrete pad construction, asphalt and concrete pavement, fire protection, fencing, housing structure construction, service connections, RNG handling equipment installation, tie-in to existing LFG infrastructure, and all associated structures, fittings, valves and appurtenances as shown on the Construction Drawings and Described in the Project Specifications.

Connections to the Biogas Cleaning Facility – Includes the supply of biogas, natural gas, and fresh water and the offtake of RNG, off-spec gas, condensate, effluent and stormwater.

LFG Blower and Flare Facility – Includes the installation of LFG blowers, utility flare, heat exchanger and ancillary piping and valves, and the construction of a building to house the blowers. This building will include a small office separated by a firewall that will house site electronics and a facility monitoring workstation.

RNG Trailer Offload Facility – Includes the installation of trailer defueling equipment, decant panel, natural gas fired boilers and booster compressors, and the construction of two buildings to house the boilers and compressors.

Metering Facility – Includes the installation of three RNG metering skids, each containing equipment to monitor gas quality from the Biogas Cleaning Facility, the Trailer Offload Facility, and the blended streams.

Gas Pipeline (alternate bid item) – Includes the installation of an approximately 2,000 ft. high pressure pipeline connecting the RNG facility to the utility pipeline interconnection.

Maintenance Building (alternate bid item) – Includes the construction of a general use maintenance building that will primarily be used for landfill compactor maintenance.

1.3 Work Covered by Contract Documents

A. Base Bid: Work of this Contract under the Base Bid includes, but is not necessarily limited to, the following major elements:

1. General Conditions
2. Mobilization and demobilization.
3. Site preparation including installation and maintenance of temporary erosion control devices (if required).
4. Site preparations including clearing and debris removal within proposed limits of construction (if required).
5. Site preparation include topsoil stripping and stockpiling for use (if required).
6. Site grading including but not limited to construction of ditches, roadway subgrades, foundation subgrades (if required).
7. Site grading to bring the site to proposed subgrade through structural filling and /or utilizing engineered fill (if required).
8. Stormwater Management including miscellaneous drainage structures such as culverts, piping, construction of the stormwater detention basin and all necessary control structures, and storm sewer to convey stormwater.
9. Installation of a landfill gas collection and conveyance system including pipe bedding, backfill, and associated appurtenances.
10. Installation of force main piping including pipe bedding, backfill, manholes/vaults and associated appurtenances
11. Construction of a non-potable water service for fire protection activities.
12. Construction of facility concrete pads for all equipment outside of the Gas Cleaning Area footprint including the transformers, knockout vessel, metering buildings, water tank, decant, heat exchanger and flare skid.

13. Construction of a Blower and Office Building, Compression Building, Boiler Building, and Metering Skid Buildings.
14. Piping and wiring interconnection between flare operations and rest of system operations.
15. Offload RNG facility equipment.
16. Construction of asphalt and concrete pavement areas including stone base and asphalt / concrete surfaces.
17. Construction of an aggregate parking area and road entrance to the proposed Maintenance Building.
18. Restoration including final grading of disturbed areas and seeding/fertilizing mulching disturbed areas.
19. Other related work described in the Contract Documents such as submittals, quality control, temporary construction facilities and controls, cleaning, protection, etc., necessary and incidental to fully execute the Work.
20. Alternates:
    a. There are Alternates Bid Items on the Bid Form. OWNER reserves the right to select none or any combination of the Alternates.
        i. Construction of the maintenance building.
        ii. 2,000 feet of transmission pipeline from the compression building to the ANR gas pipeline interconnection.

1.4 Related Work Performed by OWNER or Under Separate Contract

A. OWNER will furnish the following materials for installation by CONTRACTOR. CONTRACTOR will assist OWNER in obtaining OWNER-furnished materials to ensure that delivery dates of OWNER furnished materials do not delay the CONTRACTOR's construction schedule.

1. Water, as available on site. CONTACTOR responsible for located off-site source if needed.
2. On-site soils consisting of clay, general/structural fill and top soil.

B. OWNER will perform the following items:

1. Initial Surface Preparation.
2. Erosion control measures.
3. All earthwork associated with the RNG facility within 18-inches of final grade prior to final subgrade completion and aggregate placement and compaction. Does not include restoration work (i.e. top soil placement, seeding, and vegetation establishment).

C. OWNER will provide the following items:

1. All equipment and site work including concrete slabs inside of the Gas Cleaning Equipment footprint
2. RNG Handling Equipment (i.e. boiler, blowers, decant, RNG metering skids, electronic control devices and flare)

3. OWNER will arrange for installation of the Biogas Cleaning Equipment and Electrical Transformers. CONTRACTOR to provide all service connections to and from the Biogas Cleaning Equipment. CONTRACTOR to install all RNG Handling Equipment supplied by the OWNER. CONTRACTOR to work with OWNER or OWNERs representative to coordinate delivery and installation of all equipment.
4. Electrical from main to transformer (distribution from transformer CONTRACTOR's responsibility)
5. Natural gas from main to meter (distribution from meter is CONTRACTOR's responsibility)
6. Landfill gas collection and Control system (GCCS) tie-in (including manhole)
7. Two (2) computers for reporting and monitoring purposes
8. SCADA system
9. Construction Quality Assurance Services
10. Construction documentation and Measurements and Payments surveying (CONTRACTOR responsible for all construction layout and staking required)
11. Concrete Strength Testing
12. Asphalt Strength Testing
13. Soil Testing
14. Monitoring Well abandonment and replacement
15. Communication splice and tie-in (distribution from hand hole is CONTRACTOR's responsibility)
16. Flare system package loop-check, training and controls

1.5 Commencement of the Work

A. The CONTRACTOR shall not commence the Work nor allow any subcontractor or sub-subcontractor to commence the Work until:

1. The Contract has been fully executed or a Notice to Proceed has been issued.
2. The OWNER has approved the CONTRACTOR's performance and payment bonds, if required.
3. The OWNER has approved evidence of the CONTRACTOR's liability insurance and any other insurance required to be purchased by the CONTRACTOR.
4. The CONTRACTOR has obtained any necessary construction permits.

1.6 Project Schedule and Hours of Work

A. Anticipated Contract start date is June 18, 2018. Work shall be Substantially Complete by November 16, 2018. Final Completion of remaining items shall be completed by November 23, 2018. OWNER may be able to give CONTRACTOR approval to order long lead items prior to Start of Work in order to expedite the schedule.

B. The operation of heavy equipment and machinery shall be limited. If extended hours are necessary it should be discussed with the site operator should work start or continue outside of the normal working hours for the landfill operations. Refer to Madison General Ordinance 24.08 for additional information regarding when heavy equipment may be operated. Waste hauled to active area as part of project shall occur between 6:30 AM and 3:30 PM Monday through Friday only. No waste can be taken to active areas on Saturday unless the OWNER has manpower available to get it covered, or the CONTRACTOR covers the waste at their expense. Extensions may be granted if requested and approved by OWNER.

C. Prior to starting Work submit project schedule. Revise and resubmit to reflect actual progress relative to the proposed schedule every two weeks.

D. Project schedule shall be a comprehensive horizontal bar chart with separate bar for each major trade, subcontractor, or operation, identifying first Work day of each week. Show projected production rates and number of operating equipment on-site. Arrange schedule to indicate required sequencing of activities and to show allowances for submittals, inspections, and similar time margins.

E. Show complete sequence of construction by activity, identifying Work of separate stages and other logically grouped activities. Show projected percentage of completion of each item of Work at each Application for Progress Payment.

F. Show submittal dates required for shop drawings, product data, samples, and product delivery dates, including those furnished by OWNER.

1.7 Work Sequence

A. Coordinate work with OWNER to ensure work done will not interfere with general landfill operations.

B. Samples of off-site materials supplied by CONTRACTOR shall be tested and approved by OWNER prior to delivery to site.

C. Project shall be completed under the general sequence shown below:

1. Install erosion control and storm water management control devices prior to beginning major construction.
2. Excavate and complete undercuts/backfilling to achieve desired subbase grades.
3. Place and compact structural / engineer fill to desired subgrades.
4. Install storm sewer and culvert piping.
5. Install all below ground piping.
6. Place and compact base course at road and pads.
7. Construct building structures.
8. Place asphalt / concrete in road and parking areas.
9. Install RNG offload facility.
10. Install metering skids.
11. Install above ground piping.
12. Install leachate/condensate collection and landfill gas piping; tie-in to existing infrastructure.
13. Install surface water drainage features.

14. Install fencing.
15. Install security devices.
16. Complete site restoration.

1.8 Communications during Construction

A. Inquiries, information and coordination relating to scheduling of work, use of site, interruption of utility services, and similar matters shall be directed to the OWNER.

B. Inquiries regarding interpretation of the Contract Documents and authorization of additional work shall be directed to the OWNER.

1.9 CONTRACTOR Use of Premises

A. Refer to Section 01 00 00 Basic Requirements

1.10 Site Health and Safety Issues

A. The Work of this Contract will be performed on or adjacent to a site which may contain hazardous substances on the surface and/or subsurface. Therefore, as a minimum, satisfy applicable federal, state, and local statutes, regulations, health and safety, including but not limited to OSHA 29-CFR 1910.120, Hazardous Waste Operations and Emergency Response.

B. A site specific Health and Safety Plan shall be developed and implemented by CONTRACTOR. The CONTRACTOR shall be and remain liable for compliance with the CONTRACTOR's Health and Safety Plan by its employees, agents, and subcontractors, and shall hold ENGINEER and OWNER harmless from claims, damages, suits, expenses, and losses in any way arising from non-compliance with the CONTRACTOR's Health and Safely Plan prepared for this project site.

   1.

C. The OWNER will make available to CONTRACTOR documents and information available that relate to the identity, location, quantity, nature, or characteristics of hazardous substances near the work site. The OWNER, however, assumes no responsibility or liability for the accuracy or completeness of such documents or information, and such documents and information shall remain the property of the OWNER.

1.11 Quality Assurance / Coordination

A. CONTRACTOR is solely responsible for conformance of the Work with the Contract Documents. Review and testing by the ENGINEER or OWNER's Testing Laboratories in no way relieves the CONTRACTOR of sole responsibility for the Work and maintaining a quality assurance program.

B. Use adequate numbers of skilled workmen who are thoroughly trained, qualified, and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods needed for proper performance of the Work.

C. Provide necessary supervision, planning, scheduling, coordination, and control to perform the Work and meet the requirements of the Contract Documents.

D. Coordinate and integrate elements of Work of the various Sections of Specifications to ensure efficient and orderly sequence of installation with provisions for accommodating items installed later.

E. Verify that characteristics of elements of interrelated operating equipment are compatible; coordinate Work of various Specification Sections having interdependent responsibilities for installing, connecting to, and placing in service such equipment.

F. Key members of the CONTRACTOR's staff shall not be changed without the consent of the OWNER, unless such members cease to be employed by the CONTRACTOR in a similar capacity. Prior to commencement of the Work, select a Project Manager who shall have full responsibility for the prosecution of the Work, with full authority to act in matters as necessary for the proper coordination, direction, and administration of the Work.

G. Refer to Section 01 00 00 Basic Requirements

1.12 Warranties

A. Provide written warranties as required by respective sections of the Contract Documents.

B. Warranties shall be submitted to the OWNER and approved prior to final payment.

C. Warranties shall be in writing and shall be signed by an authorized agent for the CONTRACTOR and the Manufacturer where required.

D. Warranty periods shall start from the Substantial Completion Date of the Work as certified by the ENGINEER. In multi-year projects, warranty periods shall start from the Substantial Completion Date of each phase of the Work, as certified by the ENGINEER.

E. Within the specified warranty period, if repairs are required in connection with warranted Work as a result of materials, equipment, or workmanship, which are inferior, defective, or not in accordance with the terms of the Contract, the CONTRACTOR shall promptly upon receipt of notice from the OWNER, perform the following:

Place in satisfactory condition warranted Work, and thus correct defects therein.

Place in satisfactory condition other elements of the building or site which are damaged or disturbed in performance of warranty Work.

1.13 Defect Assessment

A. Replace the Work, or portions of the Work, not conforming to specified requirements.

B. If in the opinion of the ENGINEER the defective Work is repairable, and it is not practical to remove and replace the Work, the ENGINEER will elect one of the following remedies:

1. The defective Work may remain, but the unit sum/price shall be adjusted.
2. The defective Work shall be repaired as instructed by the ENGINEER and the unit sum/price shall be adjusted to a new sum/price at the discretion of the ENGINEER.

C. The individual specification sections may modify these options or may identify a specific formula or percentage sum/price adjustment.

1.14 Project Meetings

A. Refer to Section 01 00 00 Basic Requirements

1.15 Submittal Procedures

A. Refer to Section 01 00 00 Basic Requirements

B. Make submittals of project schedules, survey and layout data, product data, shop drawings, samples, color charts, quality control test results, photographs, warranties, etc. required by these Specifications. Submit to OWNER. Revise and resubmit as required to establish compliance with specified requirements. Mix designs shall be no more than 6 months old.

C. Prior to each submittal, verify that each item and the submittal for it conform with the specified requirements. If a submittal contains deviations from Contract Document requirements, such deviations shall be clearly noted on the submittal.

D. Submit one copy of each requested submittal. Submittals shall bear the CONTRACTOR's stamp of review and approval.

E. No portion of the Work requiring a shop drawing, sample, certification, or product data submission shall be commenced until the submission has been reviewed by the OWNER for conformity with the design intent of the Project Plans and Specifications.

F. Consecutively number submittals and indicate the applicable specification section. On resubmittals, cite the original submittal number for reference.

G. Make submittals far enough in advance of scheduled dates for installation to provide time for reviews, secure necessary approvals, revisions, resubmittals, and for placing orders and securing delivery. Allow five days for OWNER's review of submittals.

H. Review by the OWNER does not relieve the CONTRACTOR from responsibility for errors which may exist in the submitted data, including non-compliance with the Contract Documents, unless the CONTRACTOR has indicated in writing such deviation at the time of submission and written approval has been given to the specific deviation.

I. Maintain a submittal log for the duration of the Work, showing current status of submittals. Make available to OWNER upon request.

1.16 Schedule of Values

A. Submit Schedule of Values to OWNER prior to submitting first payment request. Schedule of Values shall provide a detailed breakdown of the agreed upon Contract Sum showing values allocated to each of the various parts of the Work and shall be based on the unit prices on the Contract Bid Form. Total costs of items listed in schedule shall equal the total Contract Sum. Revise and resubmit as required by OWNER.

B. Schedule of Values shall be used as a basis for CONTRACTORS's Payment Request.

C. Revise Schedule of Values to list approved Change Orders with each Application for Payment.

D. Upon request from OWNER, submit data on cost of materials, labor, equipment, overhead, and profit that will substantiate magnitude of values.

1.17 Measurement and Payment

A. Payment for lump sum work items will be based on percentage of work completed and accepted through the end of the billing period. Percentage complete will be mutually agreed upon prior to submittal of request. Lump sum payment includes full compensation for required labor, tools, products, equipment, transportation, services, and incidentals required for complete and proper erection, application, or installation of an item of the Work, including overhead and profit.

B. Lump sum payment includes full compensation for required labor, tools, products, equipment, transportation, services, and incidentals required for complete and proper erection, application, or installation of an item of the Work, including overhead and profit.

C. Payment for unit price work items shall be based on the actual quantities and measurements accepted and defined in Section 01 22 00, multiplied by the unit price of each item incorporated in the Work. Unit quantities shall be agreed upon prior to submittal of payment request.

D. Unit price payment includes full compensation for required labor, tools, products, equipment, transportation, services, and incidentals required for complete and proper erection, application, or installation of an item of the Work, including overhead and profit.

E. Estimated quantities provided on the Bid Form are for bidding purposes only. Actual quantities may and will likely vary from those estimated. If the actual Work requires more or fewer quantities than those estimated, provide the required quantities at the unit sum/prices contracted. OWNER reserves the right to reduce or increase quantities from the Bid Form.

1.18 Application for Payment

A. Refer to Section 01 00 00 Basic Requirements

1.19 Union Issues

A. Dane County Landfill is a non-union site.

*** END SECTION***

SECTION 01 22 00

MEASUREMENT AND PAYMENT

PART 1 - GENERAL

1.1 Section Includes

Procedures for measurement and payment for the Work to be done under the respective items listed in the itemized quantity listing for this project.

1.2 General

A. The following paragraphs describe measurement of and payment for the Work included under the respective items listed in the itemized bid for this contract.

B. Each lump sum and unit price stated in the itemized bid shall constitute full compensation for not only all labor, equipment and materials necessary and required to complete all work specified under that particular item including cleaning up, but also all costs for doing related work as set forth in these Specifications and/or on the Contract Drawings or implied in carrying out their intent.

C. It is anticipated that all work satisfactorily completed will be processed under monthly Payment Requests, each dated on the 30th day of each month during the construction period.

D. OWNER will provide initial topographic survey and final as-built survey in areas being constructed. All other construction staking and lay-out is the responsibility of the CONTRCTOR.

1.3 Quantities

A. Quantities indicated in the Bid Form are for bidding and contract purposes only. Actual payment quantities will be determined by measured quantities supplied or constructed and verified by OWNER.

B. If the actual Work requires quantities less than or greater than those quantities indicated in the Bid Form, CONTRACTOR will provide the required quantities at the unit prices contracted.

C. The quantities given in the Contract Documents are approximate only, and are given as a basis for the uniform comparison of bids. OWNER does not expressly or by implication agree that the actual amount of work will correspond therewith.

D. The CONTRACTOR must provide, for Unit Price Work, a proposed contract price determined on the basis of estimated quantities required for each item. The estimated quantities of items are not guaranteed and are solely for the purpose of comparing bids. Each such unit price will be deemed to include an amount for overhead, profit and indirect costs for each separately defined item.

E. An increase or decrease in the quantity for any unit price item shall not be regarded as sufficient grounds for an increase or decrease in the price of the items.

1.4 Measurement and Computation of Quantities

A. Measurement of quantities expressed as area shall be based upon a horizontal, planimetric projection to the Work limits as determined by survey Record Drawings for each item with no additional allowances for slopes.

B. Measurement of quantities expressed as volume shall be based upon comparison of survey Record Drawings performed both prior to and upon completion of each item.

C. Computation of the volume of prismoids shall be by the method of average end areas of surveyed cross sections recorded at 50 foot stations at the same locations both prior to construction and upon completion of construction of these items. Measurement of length for these items shall be recorded along the top centerline for purposes of volume computations.

D. Measurement of linear items such as piping, drainage swales, and access roads will be for quantities actually installed to the specified work limits, based upon minimum 50 foot surveyed stations (planimetric horizontal distance) recorded along the straight or curved centerline of each respective item with no additional allowances for slope.

E. No partial payments shall be made for items which have not been tested and approved.

F. Payment will be made to the limits as specified in the Contract Documents. If the constructed limits are less than the specified limit, payment will be made to the actual limits of construction as shown on the Record Drawings. Payment for quantities that exceed the specified contract limits will only be made with the approval of the OWNER/ENGINEER. The payment for quantities that exceed the contract quantities can only be obtained through an approved change order before contract quantities are exceeded.

1.5 Schedule of Contract Payment Items

A. Bid Item 101 – Mobilization and General Conditions

1. The lump sum price for this item shall be payment in full for supervision and management, ongoing project related expenses such as site health and safety, utilities, dust control, bonds, and insurances, etc., and compliance with the requirements of regulatory agencies and utilities, as well as mobilization and demobilization of all parts, material, and equipment to and from the site.

2. The price shall include, but not be limited to, the following:

   a. Supervision and management expenses such as:

      1) The salaries of Project Manager, Engineer, Superintendent, QA/QC Specialist, etc.

      2) Management travel, etc.

   b. Ongoing project related expenses such as:

      1) Transportation or delivery of all parts, material, and equipment necessary for the work to and/or from the site.

      2) Dust control.

      3) Master mechanic services.

      4) Contractor’s facilities, office trailers, and their related expenses.

      5) Vehicles and related maintenance including supplies such as fuel.

6) Sanitary facilities and related maintenance.

7) Contractor provided utilities.

8) Dewatering.

9) Preparation and submission of submittals, shop drawings, Operations and Maintenance Manual, etc.

10) Landfill gas control measures during construction, if necessary.

11) Soil erosion and sediment control during construction.

12) Protection of existing facilities to remain and protection of completed work.

13) All other related costs to complete the Project not specifically referenced in the bid tabulation.

3. Executing any and all the requirements of utility companies and regulatory agencies as pertaining to the Work.

4. Carrying out the work in compliance with the requirements set forth in the General Conditions, Supplementary Conditions, and the General Requirements.

5. Unloading and suitably storing all Owner provided materials.

6. Measurement: Lump Sum

7. Payment: This item will be payable in partial payments made monthly based on the percent complete status of the Contract as determined by the ENGINEER.

B. Bid Item 102 – Site Preparation -General

1. The lump sum payment for this item includes but is not limited to all necessary equipment, materials, and labor required for , installation and maintenance of temporary storm water control systems, construction and management of stockpiles, construction and maintenance of haul roads to and from areas under construction, borrow areas and stockpiles.

2. Measurement: Lump Sum

3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

C. Bid Item 103 - Silt Fence

1. Work includes, procurement and installation the Silt Fence required to be installed in all locations identified or described in the DRAWINGS and SPECIFICATIONS.

2. Measurement: Liner Feet

3. Payment: Payment for this item will be made monthly, until the completion of the item, based on the Linear Feet installed of the Silt Fence and approved by the ENGINEER.

D. Bid Item 104 - Silt Logs

1. Work includes, procurement and installation Silt Logs required to be installed in all locations identified or described in the DRAWINGS and SPECIFICATIONS during construction. This is for temporary erosion control and not Site Restoration which is to be performed under a separate line item.

2. Measurement: Each

3. Payment: Payment for this item will be made monthly, until the completion of the item, based on the number of completed installations of each silt log and approved by the ENGINEER.

E. Bid Item 105 – Temporary Erosion Control Matting

1. Work includes, procurement and installation of temporary erosion control matting required to be installed in all areas identified or described in the DRAWINGS and SPECIFICATIONS during construction. This is for temporary erosion control and not Site Restoration which is to be performed under a separate line item.
2. Measurement: Surveyed Square Feet of Erosion Control Mat Installed.
3. Payment: Payable based on the Square Feet of Erosion Control Mat appropriately installed per the specification.

F. Bid Item 106 - Temporary Seeding

1. Work includes, procurement and installation of temporary seeding required to be installed in all areas identified or described in the DRAWINGS and SPECIFICATIONS during construction. This is for temporary seeding and not final vegetation seeding which is to be performed under a separate line item.
2. Measurement: Surveyed Square Feet of Temporary Seeding Installed.
3. Payment: Payable based on the Square Feet of Temporary Seeding installed per the specification and approved by the ENGINEER.

G. Bid Item 107 – Excavation

1. The unit price per cubic yard (CY) for this item includes but is not limited to the excavation, hauling, stockpiling of overburden soil material, and final subbase grading to reach subbase grades as shown on the Drawings.
2. Measurement for this bid item shall be determined in-place based on actual excavated "cut" amounts by comparing a beginning surface to an ending surface over the same undercut area. Units will be in CY and quantity survey will be by or under the direction of a RLS or PE.
3. Payment for this item will be based on the actual CY quantity excavated, stockpiled, graded and as approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents .

H. Bid Item 108 – Undercut and Backfill with General Fill

1. The unit price per cubic yard (CY) for this item includes but is not necessarily limited to the removal of organic or unstable soils from within the limits of grading and refilling these areas with compacted general fill as necessary.
2. Measurement for this bid item shall be determined in-place based on actual excavated "cut" amounts by comparing a beginning surface to an ending surface over the same undercut area. Units will be in CY and quantity survey will be completed by or under the direction of a RLS or PE.
3. Payment for this item will be based on the actual CY quantity excavated, graded and as approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

I. Bid Item 109 – Undercut and Backfill with Special Fill

1. The unit price per cubic yard (CY) for this item includes but is not necessarily limited to the removal of organic or unstable soils from within the limits of grading and refilling these areas with compacted special fill as necessary.
2. Measurement for this bid item shall be determined in-place based on actual excavated "cut" amounts by comparing a beginning surface to an ending surface over the same undercut area. Units will be in CY and quantity survey will be completed by or under the direction of a RLS or PE.
3. Payment for this item will be based on the actual CY quantity excavated, graded and as approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

J. Bid Item 110 - Structural Fill

1. The unit price per cubic yard for this item shall be payment in full for transporting, placement, moisture conditioning, compaction, grading, and proof-rolling in accordance with the Plans and Specifications and in conformance with the lines, grades, details, and cross-sections shown on the Drawings.
2. Measurement for this bid item shall be determined in-place based on actual in place "fill" amounts by comparing a beginning surface to an ending surface over the same area. Units will be in CY and quantity survey will be completed by or under the direction of a RLS or PE.
3. The structural fill volume placed and within the limits specified shall be determined by surveys performed by the OWNER before and after placement is complete. Payment for this item shall be made after the placement is complete and approved by the ENGINEER based on the record drawings.

K. Bid Item 111 – RNG Area Finish Grading

1. The lump sum payment for this item includes but is not necessarily limited to preparation and finish grading of the subbase to final foot of the finished top of the aggregate layer for the RNG Gas Cleaning Area. The area designated for the Biogas Cleaning Equipment is not included in this contract.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

L. Bid Item 112 - Facility Concrete Pads

1. The lump sum payment for this item includes but is not necessarily limited to the concrete pads for the RNG Handling Equipment including the blower building, compression building, maintenance building, metering buildings, water tank decant panel, and flare skid. CONTRACTOR shall procure and install all, concrete, and other materials as necessary to complete the concrete pads for the equipment in accordance with project Drawings and Specifications.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

M. Bid Item 113 – Fixed Bollards

1. The unit price payment for this item includes but is not necessarily limited to the concrete bollards. CONTRACTOR shall procure and install all aggregate, concrete, and other materials as necessary to complete the concrete bollards in accordance with project Drawings and Specifications.
2. Measurement: Each
3. Payment: Payment for this item will be made monthly based on the number of bollards installed and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

N. Bid Item 114 – Removable Bollards

1. The unit price payment for this item includes but not necessarily limits to the removable bollards. Contractor shall procure all materials as necessary to complete the removable bollards in accordance to the project Drawings and Specifications.
2. Measurement: Each
3. Payment: Payable based on the number of bollards installed and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

O. Bid Item 115 – Aggregate Base for Paved / Parking Areas

1. The unit price per square foot (SF) for this item includes but is not necessarily limited to providing all necessary materials and labor required to procure and install the crushed stone base for pavement / parking areas in accordance with the project Drawings and Specifications.
2. Measurement for this bid item shall be determined in-place based on actual aggregate surface area as measured by a survey performed by or under the direction of a RLS or PE.
3. Payment for this item will be based on the actual SF quantity installed and as approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

P. Bid Item 116 – Asphalt Pavement Placement

1. The unit price per square foot (SF) for this item includes but is not necessarily limited to providing all necessary materials and labor required to procure and install bituminous asphaltic pavement in accordance with the project Drawings and Specifications.
2. Measurement for this bid item shall be determined in-place based on actual paved surface area as measured by a survey performed by or under the direction of a RLS or PE.
3. Payment for this item will be based on the actual SF quantity installed and as approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

Q. Bid Item 117 – Concrete Pavement Placement

1. The unit price per square foot (SF) for this item includes but is not necessarily limited to providing all necessary materials and labor required to procure and install concrete pavement in accordance with the project Drawings and Specifications.
2. Measurement for this bid item shall be determined in-place based on actual paved surface area as measured by a survey performed by a RLS or PE.

3. Payment for this item will be based on the actual SF quantity installed and as approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

R. Bid Item 118 - Aggregate Pad

1. The unit price per square foot (SF) for this item includes but is not necessarily limited to providing all necessary materials and labor required to procure and install the crushed aggregate parking area and road entrance to the Maintenance Building in accordance with the project Drawings and Specifications.

2. Measurement for this bid item shall be determined in-place based on actual aggregate surface area as measured by a survey performed by or under the direction of a RLS or PE.

3. Payment for this item will be based on the actual SF quantity installed and as approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

S. Bid Item 119 – Blower Building and Office Building

1. The lump sum payment for this item includes but is not necessarily limited to providing all necessary materials and labor required to construct and install the Blower/Office Building in accordance with the project Drawings and Specifications. RNG equipment installation to be performed under Bid Item 123. Electrical, Communication and Mechanical work to be performed under separate Bid Items.

2. Measurement: Lump Sum

3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

T. Bid Item 120 - Compression Building

1. The lump sum payment for this item includes but is not necessarily limited to providing all necessary materials and labor required to construct and install the Compression Building in accordance with the project Drawings and Specifications. RNG equipment installation to be performed under Bid Item 123. Electrical, Communication and Mechanical work to be performed under separate Bid Items.

2. Measurement: Lump Sum

3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

U. Bid Item 121- Boiler Building

1. The lump sum payment for this item includes but is not necessarily limited to providing all necessary materials and labor required to construct and install Boiler Building in accordance with the project Drawings and Specifications. RNG equipment installation to be performed under Bid Item 123. Electrical, Communication and mechanical work to be performed under separate Bid Items.

2. Measurement: Lump Sum

3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

V. Bid Item 122 - Metering Skids (**to be supplied by OWNER, Not on Contract**)

1. The unit price payment for each metering skid building includes but is not necessarily limited to providing all necessary materials and labor required to construct the metering skid buildings in accordance with the project Drawings and Specifications. Metering Skid Installations to be performed under Bid Item 12419 and the Concrete Pad construction to be performed under Bid Item 11308. Electrical, Communication and mechanical work to be performed under separate Bid Items.
2. Measurement: Each Metering Skid
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

W. Bid Item 123 – RNG Offload Facility Installation

1. The lump sum payment for this item includes but is not necessarily limited to providing all necessary materials and labor required to install the RNG processing equipment provided by the OWNER. RNG Offload Equipment shall be installed on concrete pads or in the housing buildings at locations shown in accordance with the Drawings and Specifications.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

X. Bid Item 124 – Metering Skids Installation

1. The unit price payment for this item includes but is not necessarily limited to providing all necessary materials and labor required to make necessary connections to each of the three (3) RNG metering skids. Metering skids shall be installed on the concrete pad(s) at the locations shown on the Drawings and in accordance with the Specifications.
2. Measurement: Each Metering Skid Building

   Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

Y. Bid Item 125 – Condensate Management

1. The lump sum payment for this item includes but is not necessarily limited to procurement and installation of all leachate force main piping, manholes and condensate structures, connection to the existing force main piping, and air pressure testing of the force main in accordance with the Drawings and Specifications.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

Z. Bid Item 126 – Blower/Flare Facility Installation

1. The lump sum payment for this item includes but is not limited to providing all materials and labor required to install the landfill gas blower(s), flare and associated piping and

pipe connections at the locations shown in accordance with the Drawings and Specifications.

2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

AA. Bid Item 127 – Below Ground Gas Piping

1. The lump sum payment for this item includes but is not limited to the installation of all below ground ancillary piping runs between the RNG offload facility, blower/flare facility, and metering skids as shown in the Drawings. CONTRACTOR shall be responsible for interconnecting with BioFERM equipment tie-in locations in accordance with the Drawings and Specifications.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

BB. Bid Item 128 - Aboveground Gas Piping

1. The lump sum payment for this item includes but is not limited to the installation of all above ground ancillary piping runs between the Biogas Cleaning Equipment and RNG Handling Equipment including but not limited to the:offload facility, blower/flare facility, and metering skids as shown in accordance with the Drawings and Specifications.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

CC. Bid Item 129 - Aboveground Gas Piping Tie-ins

1. The lump sum payment for this item includes but is not limited to the installation of all above ground ancillary piping interconnecting between the RNG Handling Equipment, including but not limited to the: RNG offload facility, blower/flare facility, and metering skids as shown in the Drawings. CONTRACTOR shall be responsible for interconnecting with Biogas Cleaning Equipment tie-in locations, in accordance with the Drawings and Specifications.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

DD. Bid Item 130 - GCCS Header Installation

1. The lump sum payment for this item includes but is not necessarily limited to procurement and installation of pipe and fittings to complete the Landfill Gas header piping as shown on the Drawings. Piping will be terminated with (3) blind flanges on a cross as shown on the drawings. CONTRACTOR is responsible for all trenching as necessary to complete installation.

2. MEASUREMENT: LUMP SUM

3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

EE. Bid Item 131 - Supply and Install Flow Meters, Valves, and Pressure Regulators,

1. The lump sum payment for this item includes but is not necessarily limited to procurement and installation of all flow meters, gas valves, pressure regulators and check valves along the aboveground and below ground gas piping under Bid Items 127 and 128 in accordance with the Drawings and Specifications

2. MEASUREMENT: LUMP SUM

3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

FF. Bid Item 132 - Electrical Lines

1. The lump sum payment for this item includes but is not limited to the supply and installation of all conduit, electrical wiring and fixtures between the Biogas Cleaning Equipment and the various components of the RNG Handling Equipment including all buildings and interconnections between the RNG offload facility, blower/flare facility, metering skids, in accordance with the Drawings and Specifications.

2. Measurement: Lump Sum

3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

GG. Bid Item 133 – Communication Lines

1. The lump sum payment for this item includes but is not limited to the supply and installation of all conduit and communication wiring between Biogas Cleaning Equipment and the various components of the RNG Handling Equipment within the RNG facility, including all the buildings and interconnections offload facility, blower/flare facility, metering skids, in accordance with the Drawings and Specifications.

2. Measurement: Lump Sum

3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

HH. Bid Item 134 – Mechanical

1. The lump sum payment for this item includes but is not limited to the supply and installation of all mechanical components except of those specified in Bid Item 131 between Biogas Cleaning Equipment and the various components of the RNG Handling Equipment within the RNG facility, including but not limited to the blower building, compression building, boiler building, and maintenance building in accordance with the Drawings and Specifications.

2. Measurement: Lump Sum

3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

II. Bid Item 135 – Surface Water Drainage Features

1. The lump sum payment for this item includes but is not limited to construction/installation of ditches, infiltration trenches, the supply and installation of culverts, storm sewer, storm manhole, inlet and outlet structures in accordance with the Drawings and Specifications.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

JJ. Bid Item 136 - Fire Protection

1. The lump sum payment for this item includes but is not limited to construction/installation of a non-potable water well up to 250 feet deep, pump, piping, valves, 10,000 gallon above ground water storage tank, and fire hydrant as shown in the Drawings and Specifications.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

KK. Bid Item 137 – Supply and Install Fence

1. The lump sum payment for this item includes but is not necessarily limited to procurement and installation of perimeter fencing in accordance with the Drawings and Specifications.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

LL. Bid Item 138 – Supply and Install Security Devices

1. The lump sum price for this item includes but is not necessarily limited to procurement and installation of security cameras and secure facility access points as shown in the Drawings.
2. Measurement: Lump Sum
3. Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

MM. Bid Item 139 – Traffic Signage and Pavement Markings

1. The lump sum price for this item includes but is not necessarily limited to procurement and installation of all traffic signage and pavement marking as shown on the Drawings.
2. Measurement: Lump Sum

3. Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

NN. Bid Item 140 – Site Restoration

1. The lump sum price for this item includes but is not necessarily limited to all necessary equipment, materials, and labor required to restore surfaces disturbed during construction to pre-construction conditions or better to the satisfaction of OWNER. This includes top soiling, seeding and establishing permanent vegetation.
2. Measurement: Lump Sum
3. Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER, and as determined by the Record Documents.

OO. Bid Item 141 – Stormwater Detention Basin

1. The lump sum price for this item includes but is not necessarily limited to the construction of a stormwater detention basin and all necessary control structures as shown on the drawings.
2. Measurement: Lump Sum
3. Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER, and as determined by the Record Documents.

Alternate Bid Items

Alternate Bid Item 1 – Maintenance Building

1. The lump sum payment for this item includes but is not necessarily limited to providing all necessary materials and labor required to construct and install the Maintenance Building in accordance with the project Drawings and Specifications.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

Alternate Bid Item 2 - 4-inch Diameter Steel Process Gas Piping

1. The lump sum payment for this item includes but is not limited to the installation of the processed gas pipe line from the ANR Gas Pipeline interconnection to the compression building in accordance with the Drawings and Specifications.
2. Measurement: Lump Sum
3. Payment: Payment for this item will be made monthly based on the percentage of the work related to this item that is complete and approved by the ENGINEER at the time of the pay request, and as determined by the Record Documents.

PART 2 - PRODUCTS

(Not used)

PART 3 - EXECUTION

(Not used)

SECTION 01 74 19

CONSTRUCTION WASTE MANAGEMENT, DISPOSAL & RECYCLING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Summary
2. Waste Management Goals
3. Construction and / or Demolition Waste Management
4. Waste Management Plan
5. Reuse
6. Recycling
7. Materials Sorting and Storage On Site
8. Lists of Recycling Facilities Processors and Haulers
9. Waste Management Plan Form

B. Related Sections:
1. Section 01 00 00 - Basic Requirements

1.2 WASTE MANAGEMENT GOALS

A. Dane County requires that as many waste materials as possible produced as result of this project be salvaged, reused or recycled in order to minimize impact of construction waste on landfills and to minimize expenditure of energy and cost in fabricating new materials. Additional information may be found in Dane County Green Building Policy, Resolution 299, 1999-2000.

1.3 CONSTRUCTION AND / OR DEMOLITION WASTE MANAGEMENT

A. All construction and demolition waste suitable for recycling must go to Dane County Construction & Demolition Recycling Facility located at 7102 US Hwy 12, Madison, located across from Yahara Hills Golf Course. This facility can receive mixed loads of construction and demolition waste. For complete list of acceptable materials see www.countyofdane.com/pwht/recycle/CD_Recycle.aspx.

B. Dane County Landfill, also at 7102 US Hwy 12, Madison, must receive all other waste from this project. www.countyofdane.com/pwht/recycle/landfill.aspx.

1.4 WASTE MANAGEMENT PLAN

A. Contractor shall develop Waste Management Plan (WMP) for this project. Dane County's Special Projects & Materials Manager may be contacted with questions. Outlined in RECYCLING section of this specification are examples of materials that can be recycled or reused as well as recommendations for waste sorting methods.

B. Contractor shall complete WMP and include cost of recycling / reuse in Bid. WMP will be submitted to Public Works Project Manager within fifteen (15) business days of Bid Due date. Copy of blank WMP form is in this Section. Submittal shall include cover letter and WMP form with:

1. Information on:
    a. Types of waste materials produced as result of work performed on site;
    b. Estimated quantities of waste produced;
    c. Identification of materials with potential to be recycled or reused;
    d. How materials will be recycled or reused;
    e. On-site storage and separation requirements (on site containers);
    f. Transportation methods; and
    g. Destinations.

1.5 REUSE

A. Contractors and subcontractors are encouraged to reuse as many waste materials as possible. Salvage should be investigated for materials not reusable on site.

1.6 RECYCLING

A. These materials must be recycled at Dane County Construction & Demolition Recycling Facility:

1. Wood.
2. Wood Pallets.
3. PVC Plastic (pipe, siding, etc.).
4. Asphalt & Concrete.
5. Bricks & Masonry.
6. Vinyl Siding.
7. Cardboard.
8. Metal.
9. Unpainted Gypsum Drywall.
10. Shingles.

B. These materials can be recycled elsewhere in Dane County area:

1. Fluorescent Lamps.
2. Foam Insulation & Packaging (extruded and expanded).
3. Carpet Padding.
4. Barrels & Drums.

C. All materials must be recycled at WDNR permitted waste processing facilities that adhere to all State Statutes.

1.7 MATERIALS SORTING AND STORAGE ON SITE

A. Contractor shall provide separate containers for recyclable materials. Number of containers will be dependent upon project and site conditions.

B. Contractor shall provide on-site locations for subcontractors supplied recycling containers to help facilitate recycling.

C. Mixed loads of recycled materials are allowed only per instructions at www.countyofdane.com/pwht/recycle/CD_Recycle.aspx.

1.8 LISTS OF RECYCLING FACILITIES PROCESSORS AND HAULERS

A. Refer to www.countyofdane.com/pwht/recycle/CD_Recycle.aspx for information on Dane County Construction & Demolition Recycling Facility.

B. Web site www.countyofdane.com/pwht/recycle/categories.aspx lists current information for Dane County Recycling Markets. Contractors can also contact Allison Rathsack at 608/266-4990, or local city, village, town recycling staff listed at site www.countyofdane.com/pwht/recycle/contacts.aspx. Statewide listings of recycling / reuse markets are available from UW Extension at https://www.uwgb.edu/shwec/.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

WASTE MANAGEMENT PLAN FORM

Contractor Name: ____

Address: ____

____

Phone No.: ____________________ Recycling Coordinator: ____________________

MATERIAL	ESTIMATED QUANTITY	DISPOSAL METHOD (CHECK ONE)	RECYCLING / REUSE COMPANY OR DISPOSAL SITE
Salvaged & reused building materials	_______ cu. yds. __________ tons	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Wood	_______ cu. yds. __________ tons	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Wood Pallets	_________ units	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
PVC Plastic	________ cu. ft. __________ lbs.	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Asphalt & Concrete	________ cu. ft. __________ lbs.	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Bricks & Masonry	________ cu. ft. __________ lbs.	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Vinyl Siding	________ cu. ft. __________ lbs.	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Cardboard	________ cu. ft. __________ lbs.	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Metals	_______ cu. yds. __________ tons	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Unpainted Gypsum / Drywall	_______ cu. yds. __________ tons	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Shingles	_______ cu. yds. __________ tons	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Fluorescent Lamps	________ cu. ft. __________ lbs.	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Foam Insulation	________ cu. ft. __________ lbs.	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Carpet Padding	________ cu. ft. __________ lbs.	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________
Barrels & Drums	_________ units	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:____________________

WASTE MANAGEMENT PLAN FORM

Glass	_______ cu. yds. _________ tons	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:______________________________
Other	____________	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:______________________________
Other	____________	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:______________________________
Other	____________	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:______________________________
Other	____________	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:______________________________
Other	____________	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:______________________________

SECTION 02 01 00

SITE PREPARATION

PART 1 - GENERAL

1.1 Section Includes

A. Clearing, stripping, grubbing, removing, and disposing of trees, shrubs, brush, logs, stumps, roots, windfalls, and other plant life, including dead and decayed matter, that exists within construction and designated borrow areas.

B. Installation of erosion control and temporary stormwater control measures.

PART 2 - PRODUCTS

2.1 Erosion Control Materials

A. Silt Fence: Woven or non-woven complying with WDNR Technical Standards.

B. Erosion Bales: Hay or straw, in good condition, with rectangular surfaces, tightly bound with twine.

C. Rip Rap:

PART 3 - EXECUTION

3.1 Erosion Control Material Installation

A. Erosion control materials shall be installed in accordance with the appropriate WDNR Technical Standard at the locations shown on the Construction Drawings.

3.2 Clearing and Grubbing

A. Install erosion controls prior to site clearing.

B. Remove trees, shrubs, brush, logs, stumps, roots, windfalls, and other natural growth within construction and borrow areas.

C. Remove stumps, roots, and logs to a minimum depth of 2 feet below ground surface.

D. Install silt fence w/in 10' radius of groundwater monitoring wells and gas monitoring probes.

3.3 Disposal

A. Remove debris/spoil and dispose of in a manner consistent with applicable State and Local regulations. On-site disposal is subject to discretion of landfill manager. Burning of debris is not permitted unless proper permits are obtained and permission is granted by Owner. Strip areas of topsoil prior to placing fill. Stockpile topsoil in area designated on-site.

3.4 Protection of Existing Trees and Vegetation

A. Preserve and protect from damage trees and vegetation outside the Construction / Borrow Limits.

B. Paint any cut or scarred trees and shrubs with asphaltum-base tree paint.

* * * END OF SECTION * * *

SECTION 03 10 00

CONCRETE FORMWORK

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General and Supplementary Conditions of the Construction Contract and Division 1 - General Requirements apply to the work specified in this section.

B. This section includes the design, construction and treatment of formwork and related accessories to confine and shape concrete to the required dimensions.

C. Structural notes indicated on the drawings regarding concrete formwork shall be considered a part of this specification.

1.2 QUALITY ASSURANCE

A. Codes and Standards: Comply with the provisions of the following codes, specifications, and standards except where more stringent requirements are shown or specified.

1. ACI 117 – Standard Specification for Tolerances for Concrete Construction and Materials.
2. ACI 301 – Standard Specification for Structural Concrete.
3. ACI 318 – Building Code Requirements for Structural Concrete.
4. ASTM C31 – Standard Specification for Making and Curing Concrete Test Specimens in the Field.
5. ASTM C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Test Specimens.

B. Where provisions of the pertinent Codes and Standards conflict with this specification, the more stringent provision shall govern.

1.3 SUBMITTALS

A. Formwork Release Agent: Submit data on the formwork release agent proposed for use with each form surface to be used for acceptance unless otherwise specified in the Contract Documents. Include certification that agent is compatible with finish.

B. Testing for Formwork Removal: When methods other than cylinder tests are proposed for determining time for formwork removal, submit data on methods for approval.

1.4 DESIGN REQUIREMENTS

A. Design and Engineering of formwork is the responsibility of the Contractor. Design and construct formwork, shoring and bracing to conform to Contract Documents and building code requirements. Design for construction loads, lateral pressure, and requirements of the applicable building code.

B. Drawings show the design requirements and dimensions for structural strength, but structural drawings do not show all detail dimensions to fit intricate Architectural and mechanical detail. Contractor shall so construct the concrete work that it will conform to the clearance required by the Mechanical and Electrical design.

C. Maximum deflection of facing materials forming concrete surfaces exposed to view shall be 1/240 of the center-to-center span between structural members of the formwork.

PART 2 - PRODUCTS

2.1 MATERIALS AND ACCESSORIES

A. Formwork Accessories: Use commercially manufactured accessories for formwork accessories that are partially or completely embedded in concrete, including ties and hangers.

B. Formwork Release Agent: Use commercially manufactured form release agents that will prevent formwork absorption of moisture, prevent bond with concrete, and will not stain the concrete surface. Formwork release agent shall be compatible with paint or any other finish applied to the concrete; submit data indicating compatibility.

C. Form Material:

1. No aluminum shall be allowed in the concrete work unless coated to prevent aluminum-concrete reaction.

2. Concrete form materials must be used in a manner so as to provide the surface finish specified.

3. Design formwork in accordance with the provisions of the building code or the following standards if not covered in the building code:

   a. Wood - AF & PA “National Design Specification”.
   b. Plywood - American Plywood Association “Plywood Design Specification”.
   c. Steel - AISC “Manual of Steel Construction - Allowable Stress Design”.
   d. Cold-formed Steel - AISI “Cold-Formed Steel Design Manual”.
   e. Aluminum - Aluminum Association “Aluminum Construction Manual”.
   f. Concrete - ACI 318.
   g. Other materials - as directed by manufacturer.

D. Chamfer Strips:

1. Chamfer strips shall be 3/4 inch by 3/4-inch strips.

2.2 FORM FINISHES

A. Rough Form Finish:

1. Concrete surfaces not exposed to view in the finished work shall have a rough-form finish. No form-facing material is specified for rough-form finish.

2. Set and maintain forms so finished concrete dimensions shall conform to the tolerances. Rough form finish is Designated Surface Finish-1.0 from ACI 301, except that surface tolerance Class C is required as specified in ACI 117.

B. Smooth Form Finish:

1. Concrete surfaces exposed to view in the finished work or surfaces to receive finishes of any type (paint, textured paint, etc.) shall have a smooth form finish. Form-facing material shall be plywood, tempered concrete-form-grade hardboard, metal, plastic, paper, or other acceptable material capable of producing the desired finish. Form-facing material shall produce a smooth, uniform texture on the concrete. Do not use form facing material with raised grain, torn surfaces, worn edges, patches, dents, or other defects that might impair the texture of the concrete surfaces.

2. Set and maintain forms so finished concrete dimensions shall conform to the tolerances. Smooth form finish is Designated Surface Finish-3.0 from ACI 301, including surface tolerance Class A as specified in ACI 117.

C. Patching and repairing concrete finishes are specified under Section 03 30 00.

2.3 FABRICATION AND MANUFACTURE

A. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

1. Furnish units that will leave no corrodible metal closer than 1 inch to the plane of the exposed concrete surface.

2. Furnish ties that, when removed, will leave holes not larger than 1 inch in diameter in concrete surface.

PART 3 - EXECUTION

3.1 CONSTRUCTION OF TEMPORARY FORMWORK

A. Design, erect, shore, brace, and maintain formwork to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until concrete structure can support such loads.

B. At construction joints, lap contact surface of the form sheathing for flush surfaces exposed to view over the hardened concrete in the previous placement by not more than 1 inch. Ensure formwork is held firmly against hardened concrete to prevent offsets or loss of mortar at construction joints and to maintain a true surface.

C. Unless specified in the Contract Documents, construct formwork so concrete surfaces conform to tolerance limits. The class of surface for offset between adjacent pieces of formwork facing material shall be Class C, unless specified otherwise.

D. Provide positive means of adjustment (wedges or jacks) of shores and struts. Do not make adjustments in the formwork after concrete has taken its initial set. Brace formwork securely against lateral deflection and lateral instability.

E. Fasten form wedges in place after final adjustment of forms and prior to concrete placement.

F. Anchor formwork to shores, supporting surfaces, or members to prevent upward or lateral movement of the formwork system during concrete placement.

G. Securely brace and shore forms to prevent displacement and to safely support construction loads.

H. Construct formwork for wall openings to facilitate removal and to counteract swelling of wood formwork. Keep wood forms wet as necessary to prevent shrinkage.

I. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces.

J. Do not use rust-stained steel form-facing material.

K. Unless noted otherwise, all footings shall be centered under walls, piers or columns.

L. Provide runways for moving equipment and support runways directly on formwork or structural member without resting on the reinforcing steel.

M. Place sleeves, inserts, anchors, and embedded items required for adjoining work or for support of adjoining work prior to concrete placement.

N. Position and support expansion joint material and other embedded items to prevent displacement. Fill voids in sleeves, inserts, and anchor slots temporarily with readily removable material to prevent entry of concrete into voids.

O. Projecting corners of walls and piers shall be formed with a 3/4-inch chamfer.

P. Clean surfaces of formwork and embedded materials of mortar, grout, and foreign material before concrete is placed.

Q. Cover surfaces of formwork with acceptable formwork release agent. Apply form release agent before placing reinforcing steel and concrete according to manufacturer's written instructions. Do not allow formwork release agent to puddle in forms. Do not allow formwork release agent to contact reinforcing steel or hardened concrete against which fresh concrete is to be placed

R. Clean and inspect formwork immediately before concrete is placed.

S. Provide forms for concrete work adjacent to earth banks including sides of footings.

T. Construct forms plumb and straight to conform to slopes, lines and dimensions shown.

U. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

3.2 COORDINATION

A. Install all required pipe sleeves, cavities or slots. Notify appropriate trades in due time so that they may furnish information and make necessary installations. Check sizes, location and alignment of all openings, frames and other work, which are to be built-in including electrical boxes and conduit.

B. Layout the run of partitions and establish location of openings so that other trades may properly locate their work.

C. Core drilling concrete is not permitted unless noted otherwise or approved in writing by the Engineer. Notify the Engineer in advance of conditions not shown on the drawings.

3.3 INSTALLATION OF EMBEDDED ITEMS

A. Built-In Items:

1. Confirm with Engineer that all materials to be embedded are suitable for embedment in concrete.

2. Build in anchors, inserts, and other devices indicated or required for various portions of work.

3. Build in sleeves, thimbles, and other items furnished or set in place by other trades.

4. Accurately position and support all embedded items prior to concrete placement. Secure embedded items against displacement during concrete placement operations.

5. Fill voids with readily removable material to prevent entry of concrete into voids.

6. Mechanical and electrical shall provide and set required sleeves.

7. Coordinate setting of all embedded items.

3.4 REMOVAL OF FORMS

A. When removal of formwork is based on concrete reaching a specified compressive strength, concrete will be presumed to have reached this strength when either of the following requirements has been met:

1. Test cylinders, molded and cured under the same conditions for moisture and temperature as used for the concrete they represent, have reached the specified compressive strength.

2. Concrete has been cured in accordance with the specifications for the same length of time as laboratory-cured cylinders, which have reached the specified strength. Determine the length of time concrete has been cured in the structure by the cumulative number of days or fractions thereof, not necessarily consecutive, during which the temperature of the air in contact with the concrete is above 50 degrees and the concrete has been damp or thoroughly sealed from evaporation and loss of moisture.

B. Forms shall remain in place for the following periods of time. These periods represent cumulative number days or hours, not necessarily consecutive, during which the temperature of the air surrounding the concrete is above 50 F:

1. Walls, piers, and footings: 50% specified compressive strength or minimum 24 hours.

C. When finishing is required, remove forms as soon as removal operations will not damage concrete.

D. Loosen wood formwork for wall openings when this can be accomplished without causing damage to concrete.

E. Do not allow removal of formwork to damage the fresh concrete for piers, walls, and other parts supporting the weight of the concrete. Perform needed repair and treatment required on vertical surfaces at once and follow immediately with specified curing.

3.5 FASTENER REMOVAL

A. Remove all protruding fasteners left as a result of securing inserts to forms by Contractor responsible for insert.

B. Cutting flush with surface is not acceptable.

C. Patch exposed concrete surfaces if damaged during fastener removal process.

3.6 REMOVING AND REUSING FORMS

A. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.

B. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces.

END OF SECTION

SECTION 03 20 00

CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General and Supplementary Conditions of the Construction Contract and Division 1 - General Requirements apply to the work specified in this section.

B. This section includes the fabrication and placement of reinforcing steel for concrete, and all related accessories.

C. Structural notes indicated on the drawings regarding concrete reinforcement shall be considered a part of this specification.

1.2 QUALITY ASSURANCE

A. Codes and Standards: Comply with the provisions of the following codes, specifications and standards, except where more stringent requirements are shown or specified.

1. ACI 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
2. ACI 301 - Standard Specification for Structural Concrete.
3. ACI 318 - Building Code Requirements for Structural Concrete.
4. ACI 315 - Details and Detailing of Concrete Reinforcement.
5. ASTM A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
6. ASTM A185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
7. ASTM A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
8. AWS D1.4 - Structural Welding Code - Reinforcing Steel.
9. CRSI - Manual of Standard Practice.

B. Where provisions of other pertinent codes and standards conflict with this specification, the more stringent provision shall govern.

1.3 SUBMITTALS

A. Placing Drawings: Submit placing drawings showing fabrication dimensions and locations for placement of reinforcement and reinforcement accessories. Indicate bar sizes, spacing, locations, and quantities of reinforcing steel, bending and cutting diagrams, and supporting and spacing devices. Dowels shall be shown in placing drawings for the element that is to be placed first. Reinforcing steel descriptions or shop drawings shall be inch-pound sizes.

B. Field Bending: Submit requests and procedure for field bending or straightening of reinforcement partially embedded in concrete not described in the Contract Documents.

C. Reinforcement Relocation: Submit requests to adjust reinforcement spacing necessitated by conflicts with other reinforcement, conduits, etc. for approval.

1.4 COORDINATION

A. Coordinate reinforcement installation with the placement of formwork and other embedded items such as inserts, conduit, pipe sleeves, drains, metal supports, anchor rods, etc.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver reinforcement to the jobsite in bundles sorted and labeled with durable tags indicating bar size, length, and shop drawing mark.

B. Store elevated clear of ground and protect at all times from contamination and deterioration.

C. Prevent bending, coating with earth, oil, or other material, or otherwise damaging the reinforcement.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Bar Deformations: Bars used for reinforcement shall be deformed except column spirals and welded wire reinforcement, which may be plain.

B. Reinforcing Steel: Reinforcing steel shall conform to the ASTM standard and grade indicated in the General Notes on the Drawings.

C. Welded Wire Reinforcement: Welded wire reinforcement shall conform to the ASTM standard indicated in the General Notes on the Drawings.

D. Joint Dowel Bars: Plain-steel bars. Cut bars true to length with square ends and free of burrs.

E. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete, and as follows:

1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected or CRSI Class 2 stainless-steel bar supports.

2. Concrete cast against earth: Bars may be supported by precast concrete bricks or approved prefabricated wire bar supports with footpads large enough to support the weight of the bars and construction traffic without being pushed into underlying grade. Precast concrete blocks shall have a minimum compressive strength of 6,000 psi.

F. Epoxy Anchoring System: Epoxy anchoring shall consist of a reinforcing dowel and the epoxy adhesive cartridge.

1. Reinforcing shall be as specified earlier in this Section.

2. Epoxy injection gel shall consist of a two-component structural epoxy adhesive applied in a dual cartridge dispensing system, which properly mixes the components at the point of application. Refer to General Notes for acceptable epoxy anchoring systems.

2.2 FABRICATION

A. Fabrication Tolerances: Reinforcing steel shall be shop fabricated within tolerances to conform in size, shape, quantity, dimensions, etc. to the Construction Drawings and approved Shop Drawings.

B. Bar Condition: Bars shall be free from mill scale, excessive rust and other coatings, which would reduce or destroy the bond with the concrete.

C. Bars Bending: Bars shall be bent cold, and no method of fabrication shall be used which would be injurious to the material. Heating of bars for bending is not permitted.

D. Identification: After fabrication, bars shall be sorted, bundled and tagged with metal tags bearing the bar mark before delivery to the jobsite.

E. Corner Bars: Provide corner bars to make reinforcing continuous at all times, including intersections at footings or walls. Such bars shall be the same size and spacing as the horizontal reinforcing and each leg shall have a length of at least 30 inches.

F. Reinforcing for continuous footings shall extend into spread footings a minimum of 2'-0".

G. Dowels between footings and walls or piers shall be the same grade, size and spacing or number as the vertical reinforcing respectively, unless noted otherwise.

PART 3 - EXECUTION

3.1 PLACING

A. Reinforcement Relocation: When necessary to move reinforcement beyond the specified spacing to avoid interference with other reinforcement, or embedded items, submit resulting arrangement of reinforcement to Engineer for approval.

B. Reinforcement Cutting: Cutting of reinforcement which conflicts with embedded objects is not acceptable.

C. Welded Wire Reinforcement: Extend welded wire reinforcement to within 1 inch of the concrete edge. Lap edges and ends of fabric sheets a minimum of one full mesh square plus 2”. Support welded wire reinforcement during placing of concrete to assure required positioning in the slab. Do not place wire reinforcement on grade and raise into position in freshly-placed concrete.

D. Wire Tie Orientation: Set wire ties so that ends are directed away from concrete surface.

E. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

F. Support for Reinforcement: Unless noted otherwise, supports for reinforcement shall have Class 2 protection as defined in the CRSI Manual of Standard Practice. Submit data on supports indicating class of protection at all different locations for approval.

G. Support for Bars in Concrete Cast on Ground: Bar supports for slabs on grade, footings, and all other concrete cast directly onto grade shall be supported at an average spacing of 4 feet or less in each direction.

H. Securing Reinforcing Bars: All bars must be placed, spaced, secured and supported prior to casting concrete. Bars embedded in hardened or partially hardened concrete shall not be bent unless approved in writing prior to placement by the Engineer of Record.

I. Foot Traffic: Restrict foot traffic over the slab on grade reinforcing after it has been properly positioned.

J. Reinforcement at Expansion Joints: Do not continue reinforcement or other embedded metal items bonded to concrete through expansion joints except for hairpins in slab on grade. Dowels bonded on only one side of a joint.

K. Pumping Concrete: When using a pump to place concrete, pump hose shall be supported directly on forms. Do not allow hose to rest on reinforcing bars if doing so could cause displacement of bars.

END OF SECTION

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General and Supplementary Conditions of the Construction Contract and Division 1 - General Requirements apply to the work specified in this section.

B. The work includes all items required for executing and completing the cast-in-place concrete work and related work shown on the drawings or specified herein. Work shall include installation of items furnished in other sections of these specifications.

C. Concrete paving, walks, and curbs are specified in Division 3 or 32.

D. Structural notes indicated on the drawings regarding Cast-In-Place concrete shall be considered a part of this specification.

1.2 QUALITY ASSURANCE

A. Codes and Standards: Comply with the provisions of the following codes, specifications, and standards, except where more stringent requirements are shown or specified herein:

1. ACI 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
2. ACI 301 - Standard Specifications for Structural Concrete
3. ACI 305.1 - Specification for Hot Weather Concreting
4. ACI 306.1 - Standard Specification for Cold-Weather Concrete
5. ACI 318 - Building Code Requirements for Reinforced Concrete.
6. ASTM C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
7. ASTM C33 - Standard Specification for Concrete Aggregates.
8. ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
9. ASTM C42 - Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
10. ASTM C94 - Standard Specification for Ready-Mixed Concrete.
11. ASTM C143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
12. ASTM C150 - Standard Specification for Portland Cement.

13. ASTM C157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

14. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete.

15. ASTM C172 - Standard Practice for Sampling Freshly Mixed Concrete.

16. ASTM C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.

17. ASTM C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

18. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.

19. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

20. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete.

21. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.

22. ASTM C1017 - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.

23. ASTM C1064 - Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete.

24. ASTM C1077 - Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation.

25. ASTM D1751 - Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types).

26. ASTM E154 - Standard Test Method for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover.

27. ASTM E329 –Standard Specification for Agencies Engaged in Testing and/or Inspection of Material Used in Construction

28. ASTM E1155 - Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers.

29. Concrete Reinforcing Steel Institute (CRSI) - Manual of Standard Practice.

B. Comply with all local building code requirements which are more stringent than those listed above. All referenced codes or standards shall be the most currently adopted as of the date for Receipt of Proposal.

C. Where any provision of other pertinent codes and standards conflict with this specification, the more stringent provision shall govern.

D. Maintain records verifying materials used are of the specified and accepted types and sizes and are in conformance with the requirements of the Contract Documents.

E. Use of testing services will not relieve the Contractor of the responsibility to furnish materials and construction in full compliance with the Contract Documents.

1.3 TESTING AND INSPECTION

A. Inspection and Testing:

1. The Owner shall employ an Inspection Agency to perform the duties and responsibilities specified below.

2. Refer to civil, mechanical, and electrical specifications for testing and inspection requirements of non-structural components.

3. Work performed on the premises of a fabricator approved by the building official need not be tested and inspected per the table below. The fabricator shall submit a certificate of compliance that the work has been performed in accordance with the approved plans and specification to the building official and the Owner and Engineer of Record.

4. Duties of the Inspection Agency:

   a. Perform all testing and inspection required per the Testing and Inspection Schedule indicated below.

   b. Furnish inspection reports to the building official, the Owner, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work.

   c. Submit a final signed report stating whether the work requiring Inspection was, to the best of the Inspection Agency's knowledge in conformance with the approved plans and specifications.

5. Structural Component Testing and Inspection Schedule for Section 03 30 00 is as follows:

Concrete and Concrete Placement	Continuous	Periodic	Referenced Standard
Review of proposed mix design and supporting test results		X	
Inspect bolts to be installed in concrete prior to and during placement of concrete.	X		ACI 318: 8.1.3, 21.2.8
Inspection of anchors installed in hardened concrete.		X	ACI 318: 3.8.6, 8.1.3, 21.1.8
Verifying use of required design mix		X	ACI 318: Ch. 4, 5.2-5.4

Concrete and Concrete Placement	Continuous	Periodic	Referenced Standard
At the time fresh concrete is sampled to fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete.	X		ASTM C172, ASTM C31, ACI 318: 5.6, 5.8
Inspection of concrete placement for proper application techniques	X		ACI 318: 5.9, 5.10
Inspection for maintenance of specified curing temperature and techniques.		X	ACI 318: 5.11 - 5.13
F_F and F_L slab on grade flatness testing			ASTM E1155

B. Sampling and testing requirements:

1. Take samples of fresh concrete at the job site for each mix design placed each day. Sampling and testing shall be done after the final addition and proper mixing of any water or admixtures that are added on site.

   a. Personnel and testing equipment shall meet the requirements of ASTM E329.

   b. Testing Frequency: Obtain at least one composite sample for each 150 cu. yd. or 5,000 sq. ft. of surface area, whichever is less or fraction thereof of each concrete mixture placed each day.

      1) On a given project, if the total volume of concrete is such that the frequency of testing required above would provide less than five strength tests for a given class of concrete, tests shall be made from at least five randomly selected batches or from each batch if fewer than five batches are used.

   c. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days.

2. For each sample of fresh concrete, perform the following duties:

   a. Measure and record slump in accordance with ASTM C143.

   b. Measure and record temperature in accordance with ASTM C1064.

      1) Provide one test hourly when air temperature is 40°F (4.4°C) and below and when 80°F (27°C) and above, and one test for each composite sample.

   c. Measure and record air content by volume in accordance with either ASTM C231 or ASTM C173.

d. Mold three cylinders (laboratory cylinders) in accordance with ASTM C31 to be laboratory-cured. Protect from moisture loss and maintain at 60°F to 80°F for 24 to 48 hours before moving. Deliver cylinders to testing laboratory for curing and testing.

e. Mold one cylinder (field cylinder) in accordance with ASTM C31 to be field-cured. Field cylinder shall be placed as near as possible to the in-place concrete from which it was taken, protected, and cured in the same manner. Deliver field-cured cylinder to testing laboratory, and measure and record compressive strength in accordance with ASTM C39. Field cylinder shall be used to determine if concrete footings, walls, or piers have reached the required compressive strength for steel erection to begin.

3. Measure and record compressive strength in accordance with ASTM C39 for laboratory cylinders. Test one laboratory cylinder at 7 days and all other cylinders at 28 days. Acceptance is based on the average of the two laboratory cured 28-day tests. Notify Engineer in the event strength levels do not meet the acceptance requirements of ACI 318.

   a. Any additional cylinders molded for Contractor to have a compressive strength test done before seven days shall be at the Contractor's expense.

4. Prepare and submit test reports to the Engineer, Contractor, and Supplier. Reports shall be completed and furnished within 48 hours of testing. Refer to description in Submittals.

5. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.

1.4 SUBMITTALS

A. Concrete submittals shall be separated into concrete submittals for structural concrete as specified by the specification and civil concrete as specified by the Civil Engineer.

B. Concrete Materials: Submit information on concrete materials as listed below.

1. Cementitious materials: Submit type, class, producer name, and certification not more than 90 days old of compliance with applicable ASTM standard.

2. Aggregates: Submit type, pit or quarry location, producer name, gradations, specific gravity, water content, and certification not more than 90 days old.

3. Admixtures: Submit product data sheet. Product data shall include: dosages and performance data, brand names, producers, chloride ion concentrations, and certifications of compliance with applicable ASTM standard. Certifications shall not be more than 90 days old.

4. Water: Submit name of source.

C. Product Data: Prepare and submit product and performance data for materials and accessories, including patching compounds, joint systems, curing compounds, finish materials and other concrete related items.

D. Testing Agency Qualifications: When requested, the proposed testing agencies shall submit data on qualifications for acceptance.

E. Concrete Mix Design:

1. Concrete mix design submittals shall be submitted at least 14 days prior to placing concrete.

2. Submit concrete mixture proportions and characteristics for each concrete mix. Include standard deviation analysis or trial batch data with mix design. Submit historical field test data to demonstrate the average compressive strength for approval. Concrete mix proportions, materials, and handling methods for field test data or trial batches shall be the same as used for the work. Include the following information for each mix design:

a. Water/cementitious materials ratio.
b. Slump per ASTM C143
c. Air content per ASTM C231 or ASTM C173
d. Unit weight of concrete per ASTM C138
e. Compressive strength at 28 days per ASTM C39

3. If trial batches are used, submit representative samples of each proposed ingredient to independent testing laboratory for use in preparation of mix design.

4. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments. Indicate amounts of mix water to be withheld for later addition at Project site.

5. Provide a record copy of the final mix designs and test results to the testing agency prior to commencement of the concrete work.

F. Test Reports: Submit laboratory test reports for concrete materials, mix design, compressive strength, slump, air content, and temperature. Each report shall indicate date of sampling, date of test, mix design, and location of concrete in structure.

G. Repair Methods: When stains, rust, efflorescence, and surface deposits must be removed, submit the proposed method of removal.

H. Certificates: Submit written certification regarding the design mix from the ready-mix supplier and the admixture manufacturer stating all concrete and admixtures do not contain chloride ions in excess of concentrations specified herein.

I. Adjustments: Submit any adjustments to mixture proportions or changes in materials, suppliers, or sources along with supporting documentation during the course of the work.

J. Cold Weather Procedure Submittal: Refer to Cold Weather Concreting article in Part 3 for more information.

1.5 MATERIAL DELIVERY, STORAGE, AND HANDLING

A. Cementitious materials: Store cementitious materials in dry weather tight buildings, bins, or silos that exclude contaminants.

B. Aggregates: Store and handle aggregate in a manner that will avoid segregation and prevent contamination with other materials or other sizes of aggregates. Store aggregates so as to drain freely.

C. Admixtures: Protect stored admixtures against contamination, evaporation, or damage. Protect liquid admixtures from freezing and temperature changes, which would adversely affect their performance. Handle chemical admixtures in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

A. Portland Cement: Portland cement shall conform to ASTM C150, Type I Normal, and be a standard brand of Portland cement. Use one brand of cement throughout project, unless approved in writing by the Engineer. Cement, which conforms to ASTM C150 Type II, may be used if it also meets the requirements of ASTM C150 Type I. Cement used in concrete shall be of the same brand and type as the cement used in the concrete represented by the submitted field test data or used in the trial mixtures. Maintain consistent cement color throughout project.

1. Total replacement of Portland cement by supplementary cementitious materials in design mixture shall not exceed 50% (by weight).

B. Supplementary Cementitious Materials

1. Fly Ash: Fly ash shall conform to ASTM C618, Class C or Class F. Replacement of Portland cement by fly ash shall not exceed the following (percentages are by weight):

a. Concrete Flatwork: 20 percent.
b. All other concrete: 25 percent.
c. Concrete to be placed in cold weather as defined herein: No fly ash allowed unless the cold weather procedure submitted has compensated for the increased setting time and decreased rate of strength gain due to cold weather and fly ash.

2. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

a. Ground Granulated Blast-Furnace Slab Limit: 50% by weight of total cementitious materials.
b. In mass concrete more than 2 feet thick, the usage rate may be 80% by weight of total cementitious materials.

C. Coarse Aggregate for Normal Weight Concrete: Comply with ASTM C33. Provide coarse aggregate from a single source for exposed concrete. Gradations shall be similar to that described in the following table:

COARSE AGGREGATE GRADATIONS							
SIEVE SIZE - PERCENT PASSING							
Grade No.	1-1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 16

COARSE AGGREGATE GRADATIONS							
SIEVE SIZE - PERCENT PASSING							
Grade No.	1-1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 16
4	90-100 Note 1	20-55	0-15	---	0-5		---
57	100	95-100	---	25-60	0-10	0-10	---
67		100	90-100	---	20-55	0-10	---

1. Shall be 100 percent passing the 2" sieve.

D. Fine Aggregate for Normal Weight Concrete: Comply with ASTM C33. Provide fine aggregate from a single source for exposed concrete. Fine aggregate shall consist of washed sand. Gradations shall be similar to that described in the following table:

FINE AGGREGATE GRADATIONS							
SIEVE SIZE - PERCENT PASSING							
Grade No.	3/8	No. 4	No. 8	No. 16	No. 50	No. 80	No. 100
FA	100	95-100	80-100	50-85	5-30	---	0-10

E. Do not use aggregates containing deleterious substances that could cause spalling on any exterior exposed surface. These include, but are not limited to the following:

1. Organic impurities.
2. Ferrous metals.
3. Soluble salts.
4. Coal, lignite, or other lightweight materials.
5. Soft particles.
6. Clay lumps and friable particles.
7. Cherts of less than 2.40 specific gravity.

F. Water: Mixing water for concrete shall meet the requirements of ASTM C94. Water shall be clean and free from injurious amounts of acids, alkalies, organic materials, chloride ions and oils deleterious to concrete or reinforcing steel.

G. Testing agency shall be given access to plants and stockpiles to obtain samples for testing for compliance with the Contract Documents.

2.2 ADMIXTURES

A. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures. Calcium chloride thiocyanates or admixtures containing more than 0.05 percent chloride ions by weight are not permitted.

B. Water Reducing Admixture: Material shall comply with ASTM C494, Type A. Acceptable manufacturers and products include:

1. Euclid Chemical Company - Eucon WR Series.
2. Sika Chemical Corp. - Plastocrete 161.

3. GRT – Polychem 400 NC.
4. Grace Construction Products - WRDA 82.

C. High Range Water Reducing Admixture (superplasticizer): Material shall comply with ASTM C494, Type F or Type G. Acceptable manufacturers and products include:

1. Euclid Chemical Company - Eucon 37 or Plastol Series.
2. Sika – ViscoCrete 2100.
3. GRT – Melchem.
4. Grace Construction Products - Mira 110.

D. High Range Water Reducing, Slump Retaining Admixture: Material shall comply with ASTM C494, Type F or Type G. Acceptable manufacturers and products include:

1. Euclid Chemical Company - Eucon 537, Eucon 1037, or Plastol Series.
2. Sika – Sikament 686.
3. GRT – Melchem – M.
4. Grace Construction Products – ADVA FLEX.

E. Non-Chloride Accelerator: Material shall comply with ASTM C494, Type C or Type E, and not contain a higher chloride ion concentration than municipal drinking water. Acceptable manufacturers and products include:

1. Euclid Chemical Company - Accelguard Series.
2. Sika Chemical Corp. - Sika Rapid-1.
3. GRT – Polychem HE.
4. Grace Construction Products – Lubricon NCA.

F. Air Entraining Admixture: Air entraining admixture shall comply with ASTM C260, and be certified by the manufacturer to be compatible with other admixtures to be used. Acceptable manufacturers and products include:

1. Euclid Chemical Company - Air-Mix or AEA Series.
2. Sika Chemical Corporation - Sika-Aer.
3. GRT – Polychem VR.
4. Grace Construction Products - Darex II or Daravair 1000.

G. Admixtures used in concrete shall be the same brand, type, and dosage used in concrete represented by field test data or used in trial mixes.

2.3 CURING PRODUCTS

A. Moisture Retaining Cover

1. Plastic Film: Use 6 mil polyethylene film sheet materials that meet the requirements of ASTM C171.

2. White burlap-polyethylene sheet meeting ASTM C171.

3. Reinforced Curing Paper complying with ASTM C171.

4. Moisture Retaining Fabric: A naturally colored, non-woven, polypropylene fabric with a 4-mil, non-perforated reflective (white) polyethylene coating containing stabilizers to resist degradation from ultraviolet light. Fabric shall exhibit low permeability and high moisture retention. Acceptable manufacturers and products include:

   a. PNA Construction Technologies, Inc.: Hydracure M15.
   b. Reef Industries Incorporated: Transguard 4000.

B. Dissipating Resin Curing Compound: Clear, waterborne, membrane-forming curing compound complying with ASTM C309, Type 1, Class B shall be composed of hydrocarbon resins and dissipating agents that begin to break down upon exposure to ultraviolet light and traffic approximately 4 to 6 weeks after application, providing a film that is removable with standard degreasing agents, and mechanized scrubbing actions so as to not impair the later addition of applied finishes.

   1. Curing compounds used on interior enclosed environments shall be a water-borne product and VOC compliant as required by the U.S. EPA Architectural Coating Rule.

C. Non-dissipating Curing Compound: Clear, membrane-forming curing compound complying with ASTM C309, Type 1, Class B.

   1. Curing compounds used on interior enclosed environments shall be a water-borne product and VOC compliant as required by the U.S. EPA Architectural Coating Rule.

D. Curing and Sealing Compound: Clear, membrane-forming curing and sealing compound complying with ASTM C309, Type 1, and ASTM C1315, Type 1, Class A. Compound shall dry to a clear finish, resist yellowing due to ultraviolet degradation and provide a long-lasting finish that has high resistance to chemicals, oil, grease, deicing salts, and abrasion.

   1. Curing and sealing compounds used on interior enclosed environments shall be a water-borne product and VOC compliant as required by the U.S. EPA Architectural Coating Rule.

2.4 MISCELLANEOUS MATERIALS

A. Patching Mortar: Non-shrink, non-slump, non-metallic, quick setting. Acceptable manufacturers and products:

   1. Euclid Chemical Company - Eucospeed.
   2. BASF - Thorite.
   3. Adhesive Technologies. - Hard Rok Vertipatch.
   4. W.R. Meadows - Speed Crete (Red Line).
   5. Dayton Superior – Re-Crete 20 minute.
   6. SpecChem - Precast Patch.

B. Expansion Joint Material: Preformed, resilient, non-extruding asphalt impregnated resilient fiber conforming to ASTM D1751. Thickness of expansion joint material shall be 1/2” unless noted otherwise on the drawings.

C. Insulation: Polystyrene Insulation, ASTM C578; extruded cellular type, conforming to the following:

1. Thermal Resistance R of 5.0.
2. Thickness as indicated on plan.
3. Compressive Strength Minimum: 30 psi.
4. Water absorption in accordance with ANSI/ASTM.
5. Edges: Butt.

D. Vapor Barrier: ASTM E 1745, Class A, not less than 15 mils (0.375 mm) thick. Acceptable manufacturers and products:

1. Stego Industries, LLC - Stego Wrap.
2. W.R. Meadows, Inc. - Perminator.
3. Raven Industries - Vapor Block.
4. Insulation Solutions - Viper VaporCheck II.

2.5 STRENGTH AND PROPERTIES

A. Concrete Mix Designs: Refer to Drawings for specified compressive strength. Proportion concrete mixes according to the properties in the following tables. The concrete supplier may produce a mix at a lower water-cement ratio to allow for adjustment of slump at the site by adding water. The addition of site water shall be in accordance with ASTM C94, and the total water-cement ratio shall not exceed the value specified below.

Class	Coarse Aggregate Gradation	Fine Aggregate Gradation	Range of Slump	Max. w/c	Air Content	Other Requirements
B	57 or 67	FA	1" to 4"	0.45	5% to 8%	
D	57 or 67	FA	4" to 6"	0.50	—	Use water reducing admixture to achieve slump specified
E	4 or 57	FA	1" to 4"	0.50	—	

Note: w/c = water-cementitious materials ratio.

B. Schedule of Concrete Classes: Provide concrete of the specified class according to the following schedule.

1. Footings: Class E
2. Exterior foundation walls and piers: Class B
3. Interior slabs on grade: Class D
4. Unless noted otherwise: Class B

C. Slump of Superplasticized Concrete: Concrete containing high-range water reducing admixtures (superplasticizer) shall have 8" maximum slump, unless otherwise approved by Structural Engineer. Concrete shall arrive at job site with 2" to 3" slump, be verified, then high range water reducing admixture added to increase slump to approved level.

D. Accelerators: Add non-chloride accelerator to all concrete slabs placed at air temperatures below 50°F.

E. Water Reducer: Add water reducing admixture or high range water reducing admixtures (superplasticizers) as follows:

1. All pumped concrete.
2. As required for placement or workability.
3. As required by high temperatures, low humidity, or other adverse placement conditions.
4. Concrete with water-cementitious materials ratio below 0.50.

F. No other admixtures shall be used unless approved by Structural Engineer of record.

G. Chlorides: Admixtures or other ingredients including aggregates containing calcium chloride or more than 0.05% chloride ions by weight shall not be used.

H. Workability: Concrete shall have a workability such that it will fill the forms without voids, honeycombs, or rock pockets with proper vibration without permitting materials to separate or excess water to collect on the surface.

I. Concrete Temperatures: Minimum concrete temperature of fresh concrete varies in relation to average air temperature over a 24-hour period as follows:

1.	Air temperature below 0°F	Concrete temperature 70°F min.
2.	Air temperature 0°F to 30°F	Concrete temperature 65°F min.
3.	Air temperature 30°F to 50°F	Concrete temperature 50°F min.
4.	Air temperature above 50°F	No minimum temperature

The maximum temperature of concrete at the time of delivery shall be 90°F. When concrete temperature exceeds 90°F, concrete supplier shall attempt to reduce temperature by shading aggregates and cement and cooling mix water. When these methods fail to reduce concrete temperature below 90°F, supplier shall use ice in the water to reduce the concrete temperature.

PART 3 - EXECUTION

3.1 PREPARATION

A. Do not place concrete until data on materials and mix designs have been approved and all other affected trades have coordinated their work.

B. Remove snow, ice, frost, water, mud, and other foreign material from surfaces, reinforcing bars and embedded items against which concrete will be placed.

C. Do not allow form release agent to contact reinforcing bars.

3.2 SLABS

A. Slab on Grade:

1. Where indicated on the drawings, interior slabs on grades shall have a polyethylene vapor retarder conforming to ASTM E1745. Lap all joints minimum 6” and seal edges with adhesive tape. Fit vapor retarder around utilities and seal with adhesive tape as required. Place, protect, and repair vapor-retarder sheets according to ASTM E 1643 and manufacturer's written instructions.

2. Refer to Drawings and Section 31 23 00 for required sub-grade preparation beneath slabs on grade.

3. Where vapor retarder is not used below slab on grade, wet sub-grade below slab prior to placing concrete. Subgrade shall be moist with no free water and no muddy or soft spots.

4. Saw cut control joints: Cut with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks. Control joints shall be located along column lines, with intermediate joints spaced at a maximum distance of 36 times the slab thickness, unless noted otherwise. Control Joints shall be continuous, not staggered or offset. Slab panels shall have a maximum length to width ratio of 1.5 to 1. Provide additional control joints at all reentrant or isolated corners formed in the slab on grade. Refer to Drawings for typical control joint detail.

5. Provide isolation joints around each pier and along foundation walls. Form isolation joints with 1/2" expansion joint material. Extend isolation joint material full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.

6. Verify completion of all under slab work with mechanical and electrical trades before placing slabs.

7. Slope slabs as indicated on Drawings and to provide positive drainage. Slope slab keeping bottom level and varying top. Maintain minimum thickness of concrete as indicated on Drawings. Refer to floor finishes for tolerances.

3.3 CONSTRUCTION JOINTS

A. Construction Sequence Submittal: Contractor shall submit a construction sequence indicating construction joints and the pour sequence.

B. Vertical: Locate vertical construction joints in walls not farther than a maximum of 100 feet on center.

C. Horizontal: Locate horizontal joints in walls and piers at the top of footings unless otherwise indicated. At least 24 hours shall elapse between placing concrete in a footing and placing concrete in an area supported by the walls, unless approved in writing by Structural Engineer.

D. Reinforcing: Stop all welded wire reinforcement and/or reinforcing at construction joint in slabs on grade and provide dowel bars as detailed. Provide reinforcement at other construction joints as detailed. Roughen and thoroughly clean the surface of the concrete, remove all laitance, and wet the surface before placing new concrete against the joint. Slush vertical joints with a neat cement grout before placing new concrete.

3.4 INSTALLATION – FOUNDATION PERIMETER INSULATION

A. Adhere insulation boards to foundation wall perimeter with bead adhesive.

B. Butt edges and ends tight to adjacent board and to protrusions.

C. Tape seal joints.

3.5 CONCRETE PLACEMENT

A. Place concrete as continuously as possible until placement is complete. Do not place against concrete that has attained initial set, except at authorized joints. If, for any reason, concrete pour is delayed for more than 45 minutes, bulkhead off pour at last acceptable construction joint. Immediately remove excess concrete and clean forms.

B. Do not begin to place concrete during periods of rain, sleet or snow unless adequate protection is provided.

C. No concrete shall be cast onto or against sub-grades containing free water, frost, ice or snow.

D. Do not place concrete until all reinforcement is in place, forms have been thoroughly cleaned and approval has been given.

E. Do not accept concrete delivered to the job site more than 90 minutes after initial mixing.

F. Concrete from its point of release to mixers, hoppers, or conveyances, shall not be permitted to drop more than 5 feet (10 feet for concrete containing high range water reducers). Deposit concrete directly into conveyances and directly from conveyances to final points of deposit. Sufficient transportation equipment in good working order shall be on hand before work begins. All conveying equipment must be clean and kept clean during concreting operations. Take every possible precaution to prevent segregation or loss of ingredients.

G. Deposit concrete in wall forms in layers not greater than 12 inches in depth, each layer being compacted by internal vibration before succeeding layer is placed.

H. Place concrete as near as possible to its final position to prevent segregation. Do not use vibrators to transport concrete within forms. Consolidate concrete in walls, columns, beams and slabs or joist construction thicker than 8" with internal vibrators (8,000 to 12,000 V.P.M.). Slabs less than 8" thick may be consolidated with internal vibrators (9,000 to 13,500 V.P.M.) or vibrating screeds supported on forms, boards or rails, approved by Structural Engineer, supplement vibration by forking or spading by hand along surfaces adjacent to forms and construction joints.

I. Re-tempering of concrete will not be permitted. Concrete that has obtained its initial set shall be discarded.

J. Exercise care in placing concrete over waterproof membranes, rigid insulation and/or protection boards to avoid damaging those materials. Report damage immediately, and do not proceed until damage is repaired.

K. Remove loose debris from surfaces, thoroughly wet and slush with a neat cement grout immediately before placing new concrete, or apply bonding compound to surface and let dry before placing new concrete.

L. Protect existing concrete work to be exposed to view and other finished materials from damage and staining resulting from concreting operations. Handle concrete carefully to avoid dripping and spillage. Remove spilled concrete from existing surfaces immediately. Covering sills, ledges, and other surfaces with protective coverings may be necessary to protect the work.

M. Filling In: Fill in holes and openings left in concrete structures, unless otherwise indicated, after work of other trades is in place. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete Work.

N. Concrete piers for metal building columns: Metal building columns are installed without grout pad. Concrete Contractor shall modify top of piers as required to get concrete piers to the correct elevation. Contractor to submit modification procedures to Engineer of Record for review.

3.6 CONCRETE FINISHES AND TOLERANCES

A. Exposed Smooth Formed Surfaces: Remove forms and perform necessary repairs and patch to produce surface finish-3.0 as specified in ACI 301. Apply the following to smooth-formed finished concrete exposed to view in the finished work.

1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.

B. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

3.7 CONCRETE SLAB FINISHES AND TOLERANCES

A. Trowel Finish:

1. Screed concrete to an even plane, float, then power trowel the surface.

2. Hand trowel the surface smooth and free of trowel marks. Continue hand troweling until a ringing sound is produced as the floor is troweled.

3. Provide trowel finish as indicated on the Drawings and at the following locations:

a. Concrete floors exposed in finished work unless otherwise indicated.

B. Fine Broom Finish:

1. Screed concrete to an even plane, float, then power trowel the surface. Provide fine hair broom finish perpendicular to slope, free of loose particles, ridges, projections, voids and concrete droppings.

2. Provide fine broom finish as indicated on the Drawings and at the following locations:

a. Stoop slabs.

C. Floor Finish Tolerances: Floor finish tolerances as measured in accordance with ASTM E1155, Standard Test Method for Determining Floor Flatness and Levelness Using the F-Number System (Inch Pound Units), shall be as follows:

Floor Profile Quality Classification	Minimum Flatness Number Required			
	Test Area		Minimum Local F-Number	
	Flatness F_F	Level F_L	Flatness F_F	Level F_L
Slab on Grade	25	20	15	12

D. Slab Drainage: Finish all concrete slabs to proper elevations to ensure that all surface moisture will drain freely to floor drains, and that no puddle areas exist. Contractor shall bear the cost of corrections to provide positive drainage.

E. Special Tolerances for Concrete Slabs: No abrupt change in vertical elevation of 1/4" or more is acceptable at the interface between slabs and within areas where pedestrian traffic is expected.

3.8 CONCRETE CURING

A. Freshly placed concrete shall be protected from premature drying and excessively hot temperatures.

B. Concrete other than high-early strength shall be maintained above 50°F and in a moist condition for at least the first 7 days after placement, except when special curing is used. Special curing procedures shall not be used without written permission from the Structural Engineer of Record.

C. Formed surfaces shall be cured by leaving the formwork in place during the curing period.

D. Protect concrete from excessive changes in temperature during the curing period and at the termination of the curing process. Changes in the temperature of the concrete shall be as uniform as possible and shall not exceed 5°F in any one hour or 50°F in any 24-hour period.

E. Protect concrete from injury from the elements until full strength is developed. Protect from mechanical injury.

F. During cold weather construction, all footings shall be protected from frost penetration until the building is enclosed and temporary heat is provided.

3.9 SLAB CURING

A. Begin curing after finishing concrete, but not before free water has disappeared from concrete surface. Use one of the methods described below.

B. Moisture-Retaining-Cover Curing for Concrete Floors Not Exposed in Final Condition: Cover concrete surface with waterproof sheet material as soon as finishing operations are complete and the concrete is sufficiently hard to be undamaged by covering. The cover shall be placed flat on the concrete surface, avoiding wrinkles. Sprinkle concrete with water as necessary during application of covering. Place in widest practicable width, with sides and ends lapped at least 12 inches, and seal with waterproof tape or adhesive. Verify that the concrete is continuously wet under the sheets; otherwise, add water through soaker hoses under the sheets. Weight down covering to prevent displacement. Immediately repair any holes or tears during the curing period using polyethylene sheet and waterproof tape. Curing process shall be maintained for a minimum of 7 days.

C. Moisture-Retaining-Fabric Curing for Concrete Floors to Remain Exposed: Cover concrete surface with moisture retaining fabric as soon as finishing operations are complete and the concrete is sufficiently hard to be undamaged by covering. The cover shall be installed in accordance with manufacturer's written recommendations, in largest practical widths. Wet the slab to rejection, then thoroughly wet fabric side of cover and install with poly side up. Lap over adjacent covers a minimum of 18". Wet all laps and outside edges to prevent displacement and to ensure intimate contact with concrete and adjacent covers. Rewet as necessary and protect covers from damage during curing process.

1. After minimum 7-day cure, remove moisture retaining fabric in sections.

2. A maximum of 3,500 square feet of concrete curing cover may be removed at any one time. At no time shall the exposed area be permitted to dry prior to completion of the floor scrubbing process.

3. Using a high-powered floor scrubber capable of a minimum 80 pounds head pressure, and a mild citrus-based detergent that does not damage or mar the surface in any way, scrub the floor to remove any minerals or soluble salts that may have accumulated at the floor surface. Rinse area thoroughly with clean fresh water. Remove water and allow floor to dry. If whitening occurs during drying, repeat scrubbing process before floor dries until no whitening occurs during drying.

4. All areas of the floor shall remain wet during floor scrubbing process. Expose only the amount of floor surface that can be cleaned before any drying occurs without exceeding the maximum allowable exposed area.

D. Curing Compound: Apply uniformly in continuous operation by low pressure spray equipment or roller as soon as finishing operations are complete, free water on the surface has disappeared and no water sheen can be seen. Follow the manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period. Verify compatibility of the curing compound with paint, finishes, or toppings that require positive bond to the concrete. If curing compound is not compatible with paint finishes or toppings, utilize a dissipating curing compound and remove in accordance with the manufacturer's recommendations.

3.10 APPLICATION OF FLOOR SEALER - FINISH COAT

A. Give concrete floors second coat of curing and sealing compound immediately prior to Substantial Completion.

B. Clean floors and apply sealer strictly according to manufacturer's instructions. Dilution and coverage shall be as recommended by the manufacturer. Apply sealer evenly.

3.11 COLD WEATHER CONCRETING

A. Definition: Cold weather shall be defined as a period when for more than three successive days the average daily outdoor temperature drops below 40°F. The average daily temperature is the average of the highest and lowest temperature during the period from midnight to midnight. When temperatures above 50°F occur during more than half of any 24-hour duration, the period shall not be regarded as cold weather.

B. All cast-in-place concrete work occurring during cold weather shall conform to all requirements of ACI 306.1, “Standard Specification for Cold Weather Concreting”, published by the American Concrete Institute, Detroit, Michigan, except as modified by the contract documents or this specification.

C. Planning: The General Contractor, concrete contractor, concrete supplier and the Engineer shall have a pre-construction conference to outline the cold weather concreting operations concerning the placing, finishing, curing and protection of the concrete during cold weather. Pre-construction conference shall occur before cold weather is expected to occur.

D. Detailed procedure submittal: Concrete contractor shall prepare and submit for review detailed procedures for the production, transportation placement, protection, curing and temperature monitoring of concrete during cold weather. Include procedures to be implemented upon abrupt changes in weather conditions. Do not begin cold weather concreting until these procedures have been reviewed and approved.

E. Mixing: Concrete flatwork poured in cold weather shall be proportioned to obtain a lower slump to minimize the amount of bleed water during finishing. All bleed water should be skimmed off flatwork prior to troweling. Concrete that will be exposed to cycles of freezing and thawing while saturated should be properly air entrained as outlined in this specification.

F. Protection of Concrete: Cure and protect concrete against damage from freezing for a minimum period of 72 hours, unless approved by the structural engineer. The protection period may be reduced according to ACI 306.1 requirements. Concrete contractor shall submit a letter of request to reduce the protection period, by outlining the method used to achieve the reduction per ACI 306.1.

1. When practical for the construction schedule, formwork shall be insulated and remain in place for at least the required protection period.

G. Concrete Temperatures: The minimum temperature of concrete immediately after placement shall be as specified in the following table.

Section Size	Minimum temperature of concrete as placed and maintained during the protection period	Maximum gradual decrease in surface temperature during any 24 hours after the end of the protection.	Mixing Temperatures		
			Above 30°F	0 to 30°F	Below 0°F
< 12 in	55°F	50°F	60°F	65°F	70°F

Section Size	Minimum temperature of concrete as placed and maintained during the protection period	Maximum gradual decrease in surface temperature during any 24 hours after the end of the protection.	Mixing Temperatures		
			Above 30°F	0 to 30°F	Below 0°F
12-36 in	50°F	40°F	55°F	60°F	65°F
36-72 in	50°F	30°F	50°F	55°F	60°F
> 72 in	50°F	20°F	45°F	50°F	55°F

H. Mixing Temperatures: As the ambient air temperature decreases the concrete mixing temperature shall be increased to compensate for the heat lost in the period between mixing and placement. The concrete supplier shall use one or both of the following methods for increasing the concrete temperature.

1. Heating the mixing water to a temperature necessary to offset the temperature losses during transport. Supplier shall not heat water to temperatures in excess of 140°F, without taking special precautions as outlined in ACI 306.

2. Heating the aggregate with a circulated steam piping system.

I. Temperature measurements: The Contractor shall be responsible for monitoring and recording the concrete temperatures during placement and throughout the protection period.

1. Inspection personnel shall keep a record of the date, time, outside air temperature, temperature of concrete as placed, and weather conditions.

2. Temperature of the concrete and the outside air shall be recorded at regular intervals but not less than twice in a 24-hour period. The record shall include temperatures at several points within the enclosure and on the concrete surface of sufficient frequency to determine a range of temperatures.

3. Inspection agency shall submit the temperature logs to the Engineer for permanent job records.

3.12 HOT WEATHER PROTECTION

A. Definition: Hot weather shall be defined as any combination of high ambient temperature, low relative humidity, high winds and intense solar radiation that leads to higher than usual evaporation. The table below defines low relative humidity based on air temperature. For a given air temperature, if the relative humidity is equal to or less than the specified minimum, provisions for hot weather concreting shall be as follows:

Air Temperature	Minimum Relative Humidity
105°F	90%
100°F	80%
95°F	70%
90°F	60%
85°F	50%

Air Temperature	Minimum Relative Humidity
80°F	40%
75°F	30%

B. Scheduling: When hot weather is expected, adjust concrete placement schedules to avoid placing or finishing during the period from noon until 3:00 pm. When possible, slab pours should be delayed until the building is enclosed to protect the concrete from wind and direct sunlight, Construction schedule shall account for 7-day moist curing period.

C. Mixing: Concrete supplier shall adjust mix designs and admixtures to minimize slump loss. Concrete shall be mixed at a water-cement, which is lower than the specified maximum to allow for the adjustment of slump by addition of water in the field. Water reduction shall be accomplished without reducing initial slump by increasing dosage of water reducing admixture.

D. Preparation: Do not order concrete earlier than is required to avoid delays. Cool forms, subgrades and reinforcing bars with water spray from fog nozzle prior to concrete placement.

E. Delivery: Site traffic shall be coordinated and delivery times scheduled to minimize waiting times for concrete trucks.

F. Placement: Preparations shall be made to place and consolidate the concrete at the fastest possible rate. Maintain a continuous flow of concrete to the job site to avoid development of cold joints, during placement of slabs, apply fog spray to prevent moisture loss without causing surplus water to stand on concrete surface.

G. Finishing: Finish concrete as fast as practical. Continue fogging concrete during finishing. Where fogging is not possible, apply sprayable moisture-retaining film between finishing passes.

H. Curing: Formed concrete shall be covered with a waterproof material to retain moisture. Flat work shall be moisture cured as described in this specification. Moist curing shall continue for at least 7 days.

3.13 FIELD QUALITY ASSURANCE

A. Independent Testing Agency and Inspector shall each perform their prescribed inspection, sampling, and testing services as described in Part 1 of this specification section.

B. In cases where samples have not been taken or tests conducted as specified or strength of laboratory test cylinders for a particular portion of the structure fails to meet requirements of ACI 301, for evaluation of concrete strength, Structural Engineer shall have the right to order compressive or flexural test specimens or both be taken from the hardened concrete according to ASTM C42, load tests according to ACI 318, or such other tests as may be necessary to clearly establish the strength of the in situ concrete, and such tests shall be paid for by the Contractor.

3.14 REPAIR OF DEFECTIVE AREAS

A. All repair of defective areas shall be made, with prior approval of Engineer, as to method and procedure, in accordance with Section 5 of ACI 301, except specified bonding compound must be used.

B. Patch form tie holes at the following locations:

1. Unfinished exposed concrete (not scheduled for painting, plus at board formed concrete finish).

2. All other areas: Prime voids with bonding compound and fill with patching mortar. Strike flush without overlap, float to uniform texture to match adjacent surfaces.

3. Exposed areas:

a. Remove projections, ridges and other protrusions not conforming to requirements specified under Section 03 10 00.
b. Fill voids and pin holes not conforming to requirements specified under Section 03 10 00.

C. All structural repairs shall be made, with prior approval of the Engineer, as to method and procedure, using the specified epoxy adhesive and/or epoxy mortar.

D. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.

1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch in any dimension in solid concrete but not less than 1 inch in depth. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.

2. Repair defects on surfaces exposed to view by blending white Portland cement and standard Portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.

3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Engineer.

E. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.

2. After concrete has cured at least 14 days, correct high areas by grinding.

3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.

4. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.

5. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least 3/4-inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mix as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.

6. Repair random cracks and single holes 1 inch or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

3.15 CLEANING

A. Clean exposed concrete to remove laitance, efflorescence and stains.

END OF SECTION

SECTION 13 34 19

METAL BUILDING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General and Supplementary Conditions of the Construction Contract and Division 1 - General Requirements apply to the work specified in this section.

B. This section includes metal building systems that consist of integrated sets of mutually dependent components as shown on the drawings and specified herein. Work shall include, but not be limited to, the following items:

1. Structural steel framing and sub-framing
2. Complete metal roof system.
3. Complete metal wall system.
4. Soffit panel system.
5. Sheet metal flashing and trim.
6. Wall and roof insulation.
7. Gutters, downspouts, trim and accessories,
8. Miscellaneous fasteners and accessories as required for erection of the metal building.
9. Doors.
10. Windows.

C. The intent of this specification is to establish a quality and performance level for buildings as shown on the contract documents.

D. The General Contractor shall coordinate the requirements of other specific building systems and other project features, including mechanical and electrical requirements, site and foundation requirements, and construction of the interior of the metal building.

E. Mechanical, Equipment, and Electrical Contractors shall provide the following information to the General Contractor for use in the design of the metal building system:

1. Dead load of all hanging items, including pipes and equipment.
2. Requirements for support.
3. Location of all roof and wall openings.
4. Support requirements of roof and wall openings.

F. The building shall be designed and detailed by the Metal Building Contractor. This contractor is responsible for submittal of the design and engineering documents for the metal building system, sealed by a Structural Engineer licensed in the state in which the project is located to the building department for review and approval.

G. References in the drawings to the pre-engineered building (PEB), PEB. manufacturer, and similar terminology refer to the work of this section.

H. Structural notes indicated on the drawings regarding metal building manufacturer shall be considered a part of this specification.

I. No substitutions will be allowed without the Engineer's approval.

J. Refer to the following specification divisions for additional information:

1. Division 3 for "Cast-in-Place Concrete" for concrete foundations.

1.2 QUALITY ASSURANCE

A. Codes and Standards: Comply with the provisions of the following codes, specifications, and standards, except where more stringent requirements are shown or specified.

1. AISC – Specification for Structural Steel Buildings – Allowable Strength Design (ASD) 13th Edition.

2. AISC - Specification for Structural Joints Using High-Strength Bolts.

3. AISC - Code of Standard Practice for Buildings and Bridges.

4. ASTM A36 - Standard Specification for Carbon Structural Steel.

5. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

6. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

7. ASTM A500 - Standard Specification for Cold Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

8. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts.

9. ASTM A572 - Standard Specification for High Strength, Low-Alloy Columbium-Vanadium Structural Steel.

10. ASTM A992 - Standard Specification for Steel for Structural Shapes for use in Building Framing.

11. ASTM A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

12. ASTM E1592 D - Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference.

13. ASTM F436 - Standard Specification for Hardened Steel Washers.

14. ASTM F1554 - Standard Specification for Anchor Bolts, Steel 36, 55 and 105 ksi Yield Strength

15. ASTM F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength, Inch Dimensions.

16. AWS D1.1 - Structural Welding Code.

17. ASTM C991 – Standard Specification for Flexible Glass Fiber Insulation for Metal Buildings.

18. SSPC - Steel Structures Painting Council.

19. UL 580 - Underwriters Laboratories - Test for Wind Uplift Resistance of Roof Assemblies.

20. "Low Rise Building System Manual", Metal Building Manufacturer's Association. (MBMA).

21. "Cold Formed Steel Design Manual", American Iron and Steel Institute (AISI)

B. Where any provisions of other pertinent codes and standards conflict with this specification, the more stringent provision shall govern.

C. Manufacturer's Qualifications: Provide a metal building system manufactured by a company with five (5) years' experience in manufacturing the type of metal building system similar to the one indicated for this project and have a record of successful in-service performance.

1. Engineering Responsibility: Preparation of shop drawings and engineering analysis by a qualified Structural Engineer registered in the state in which the project is located.

D. Installer's Qualifications: Installer shall be certified in writing by metal building manufacturer as qualified for erection of the manufacturer's product. The installer shall have a minimum of five (5) years' experience in the erection of the type of metal building system similar to the one indicated for this project.

E. Single Source Responsibility: Obtain the metal building system components, including the structural framing, wall and roof covering, and accessory components, from one single manufacturer.

F. Tolerances: Tolerances shall be as indicated by the AISC Code of Standard Practice for Buildings and Bridges, except that tolerances for fabricating, rolling, cambering and erection shall not be cumulative.

1.3 SYSTEM DESCRIPTION

A. Building Description:

1. Drawings indicate basic building layout for member sizes, profiles, dimensional requirements, lateral system locations and lateral system types. Do not modify the intended aesthetic effects or system layout without Architect's and Engineer's approval. If modifications are proposed, submit comprehensive explanatory data for review.

2. Primary Framing:

   a. The primary structure shall be a rigid clear span frame with I-shaped tapered columns and tapered depth rafters of shop welded steel plates without interior columns.

3. End Wall Framing:

   a. The end wall framing shall be manufacturer's standard framing, with load bearing I-shaped columns along the wall and at the corners.

4. Secondary Framing: Z or C purlins, girts, eave struts, ridge members, flange bracing, clips and other accessories required.

   a. Girts to be as shown on the drawings.

   b. Girts to be bypass.

5. Overhead Door Framing: Steel channels framing the door openings. Include wall support for door torsion spring and roof support for track.

6. Bay spacing: As shown on the drawings.

7. Roof Slope: As shown on the drawings.

8. Minimum Eave Height: As shown on the drawings.

9. Roof System: Manufacturer's standard with insulation.

10. Gutters and Downspouts: Manufacturer's standard gutter and downspout profile. Size by manufacturer. Downspout spacing by manufacturer at locations shown on drawings.

11. Base Plates and Anchor Rods:

    a. Column base plates have pinned bases that do not transfer moments to the foundations.

    b. Base plates shall not have a grout pad underneath the base plate.

    c. Base plate tension forces are resisted by anchor rods. Metal building designer to design anchor rods for tension.

    d. Rigid frame base plate shear forces are resisted by anchor rods. Metal building designer to design anchor rods for shear.

e. Anchor rod embedment to be designed by IMEG. Design to be completed once shop drawings are submitted with building reactions. For bid purposes, use anchor rod embedment of 12 times anchor rod diameter, unless noted otherwise.

B. All metal building components shall be designed under the direct supervision of a registered Structural Engineer, licensed in the state in which the project is located.

C. Design Loads:

1. Building Code: IBC 2009.

2. Building Occupancy Category: II

3. Roof Design Dead Load:

a. Building Self-Weight: by metal building designer.

b. Superimposed Dead Load (Collateral Dead Load): 5 psf minimum. Total dead load (self-weight plus collateral) is 20 psf minimum (owner requirement).

c. Concentrated Equipment Loads: Mechanical, Electrical, and Equipment Contractors shall provide the dead load weight of all hanging equipment weighing more than 100 lbs. to the General Contractor for use in the design of the metal building system.

4. Live Loads:

a. Roof: 20 psf roof live load.

5. Snow Load:

a. Uniform load as shown on the drawings.

b. Drift load as shown on the drawings.

6. Wind Load:

a. Main wind force resisting system: as shown on the drawings.

b. Components and cladding: per ASCE 7-05.

7. Seismic Load: Metal building engineer to design metal building systems capable of withstanding the effects of earthquake motions determined according to ASCE 7-05. Refer to drawings for additional site information.

8. Rain Load:

a. Minimum per code.

9. Load Combinations: As required by the building code specified.

10. Deflection Criteria: Design the assemblies to withstand design loads with deflections no greater than the following:

    a. Roof and Wall Panels: 1/180 of the span for total load.

    b. Purlins: 1/120 of the span for vertical total load and 1/240 of the span for vertical live load.

    c. Girts: 1/120 of the span.

    d. Primary Framing Members:

        1) Wind: 1/90 of the building height under specified wind pressure (50-year recurrence interval).

        2) Seismic: Per ASCE 7-05 allowable story drift.

    e. End Wall Wind Columns: 1/180 of the column length.

11. Design the secondary framing to accommodate deflection of primary building's structure and construction tolerances, and to maintain clearances at openings.

12. Thermal Movements: Provide metal panel systems that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base engineering calculation on the surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

    a. Temperature Change (range): 150°F, ambient, 180°F material surfaces.

13. Thermal Performance: Provide metal panel assemblies with the following minimum R-values:

    a. Thermal Resistance of Wall Insulation: R-13

    b. Thermal Resistance of Roof Insulation: R-19

D. Provide drainage to exterior for water entering or condensation occurring within wall or roof system.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide overhead coiling doors capable of withstanding the effects of gravity loads and the following loads and stresses without evidencing permanent deformation of door components:

1. Wind Load: Uniform pressure (velocity pressure) of 25 lbf/sq. ft. acting inward and outward.

2. Impact Test for Flying Debris: Comply with ASTM E1996, tested according to ASTM E1886.

    a. Level of Protection: Basic Protection

b. Wind Zone: 90 mph, pressure test to 1/2 and 1-1/2 x design pressure (positive and negative).

B. Operation-Cycle Requirements: Provide overhead coiling door components and operators capable of operating for not less than 20,000 cycles and for 40 cycles per day.

1.5 SUBMITTALS

A. Design Calculations: Submit four (4) copies of the design calculations prepared under the direct supervision of a registered Structural Engineer licensed to practice in the state in which the project is located. All copies of the calculation shall bear the Engineer's State seal and signature. The calculation package shall include, but not be limited to, the following information:

1. Load reactions for all metal building columns: Submit diagram indicating building column reactions along all three principal axes to the General Contractor for foundation design. Loads shall be provided as unfactored service loads and broken out into dead loads, live load, snow load, wind load, and earthquake load components.

2. Frame analysis for all the building frames for this project: Analysis shall indicate the loads applied, the load combination used for the analysis, the member forces for all load combinations, the calculated deflections for all load combination and the actual stress/allowable stress ratios for all load combinations.

3. Structural analysis of the roof purlins and wall girts for the all-applied load combinations: Include calculated member deflections and forces.

4. Allowable span tables and allowable load table for the roof and wall panels. Indicate all loads used to select the roof and wall panels.

5. Lateral force resisting system analysis indicating the member stresses, the calculated deflections, and the connection design.

6. Anchor rod and base plate calculations for all metal building columns.

B. Shop Drawings:

1. Prepare and submit complete erection and detailed shop drawings prepared by or under the direct supervision of a Structural Engineer legally authorized to practice in the jurisdiction where the Project is located for Engineer's approval.

2. Structural Framing: Shop drawings shall indicate dimensions, locations of structural members, methods of connecting, anchoring, fastening, bracing, openings, cambers, loads and support reactions.

3. Roof and Wall Panels: Provide layouts plans of all wall and roof panels, include details of roof edge conditions, joints, corners, custom profiles, supports, anchorage, trim, flashings, closures and methods of installation.

4. Building Accessory Components: Provide details of metal building accessory components to indicate the method of installation.

a. Provide details of gutters, downspouts and other sheet metal accessories.

b. Provide details of all special framing, flashing, and trim required for the roof and wall openings for mechanical and electrical system components.

5. Connection and framing details for all building frames, sidewalls, end-walls, and roof-framing members.

6. Welder's Certification: Submit certification for all welders employed on the project demonstrating they have been AWS qualified to perform the welding procedures required for this project.

7. Provide anchor rod setting plans for use by IMEG and the concrete contractor.

8. General Contractor to provide copies of field concrete cylinder breaks indicating the concrete meets 75% of the design compressive strength to the steel erector.

C. The General Contractor shall conduct a field survey of as-built anchors and bearing plate locations and elevations prior to steel erection. Survey shall be furnished to the steel fabricator. Contractor shall identify deviations from approved shop drawings and submit proposed repairs and modifications to the metal building manufacturer and Engineer for approval.

D. Product Data: For each type and size of overhead coiling door and accessory.

E. Permit Drawings: Submit to the building department having jurisdiction for this project, documents adequate for their review and approval, prepared by and bearing seal of a Structural Engineer licensed in the state in which the project is located.

F. Color Samples: Submit to the Owner and Engineer the manufacturer's standard color charts or chips showing the full range of colors, textures, and patterns available for the metal roofing and wall panels with factory-applied finishes.

G. Product Samples: Provide sample panels, 12" long by actual panel width, demonstrating the panels' style, profile, color, and texture indicated for the Owner and Engineer to review.

H. Provide a letter of certification from the metal building manufacturer indicating that the installer is qualified for the erection of the manufacturer's products.

I. Maintenance Data: For metal panel finishes and door hardware to include in maintenance manuals.

J. Door Schedule: For doors and frames. Use same designations indicated on the drawings. Include details of reinforcement and attachment to secondary framing.

K. Door Hardware Schedule: Include details of fabrication and assembly of door hardware. Organize into door hardware sets indicating complete designations of every item required for each door or opening.

L. Keying Schedule: Detail Owner's final keying instructions for locks. Include schematic keying diagram and index each key set to unique door designations. Match existing doors where required by Owner.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Building members shall be transported, stored and erected in a manner that will avoid any damage or deformation. Materials should be stored to allow easy access for inspection and identification. Bent or deformed members will be rejected and shall be replaced or repaired at the expense of the responsible party. Store clear of the ground and in such a manner as to eliminate excessive handling. Bent or deformed items will be rejected and shall be replaced or repaired at the expense of the responsible party.

B. Store fasteners in a protected location. Clean and re-lubricate bolts and nuts before use.

C. Protect insulation from the elements. Do not expose to rain and complete installation and concealment of insulation as rapidly as possible in each area of construction.

1.7 WARRANTIES

A. All Components: Manufacturer’s standard one (1) year workmanship warranty.

B. Roofing and Siding Panels Finish Warranty: Furnish the roofing and siding panel manufacturer’s written warranty, covering failure of the factory-applied exterior finish on metal wall and roof panels within the warranty period.

C. Roof Panels: Manufacturer’s standard 20-year paint finish warranty.

D. Wall Panels: Manufacturer’s standard 20-year paint finish warranty.

E. All warranties shall commence after the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 STANDARD OF QUALITY

A. The framing system shown in the bid set for this metal building has been laid out based on the framing system manufactured by Nucor Building Systems, and details and specifications are based on their products.

B. Bidders may use equivalent metal building system packages by the listed manufacturers, subject to the following:

1. The metal building package shall consist of components and accessories as shown on the drawings and called out in these specifications, equivalent to those shown or specified. Wall and roof systems must be equivalent in appearance and performance characteristics.

2. The proposed package complies with all applicable standard specifications, design standards, design loads, and design load combinations.

3. The bid shall be accompanied by a written outline of any revisions that must be made to the proposed framing layout or any other components of the total building in order to accommodate the metal building package of another manufacturer.

4. Product data of roof and wall panels proposed for use in place of the Nucor products shall accompany the bid.

2.2 ACCEPTABLE MANUFACTURERS

A. The following manufacturers are acceptable provided they can furnish all components that meet the specification requirements:

1. Nucor Building Systems
2. Star Building Systems
3. Butler Manufacturing Company
4. Ceco Building Systems
5. Behlen Buildings
6. Chief Buildings
7. Gold Seal Steel Buildings
8. As approved substitution

2.3 MATERIALS

A. Structural Metal:

1. All structural metal shall be free from defects impairing strength, durability or appearance. All structural metal shall meet the latest minimum requirements as follows:

   a. Structural Steel Plate, Bar, Channel, Angle, Sheet, and Strip: ASTM A36; or ASTM A572, ASTM A529, or ASTM A992, Grade 50 or 55.

   b. Structural Steel W-shapes: ASTM A529, ASTM A572, or ASTM A992, Grade 50 or 55.

   c. Galvanized Steel Sheet: ASTM A653, structural quality, Grade 50, with G60 coating.

   d. Aluminum Zinc-Coated Steel Sheet: ASTM A792, Grade 40.

   e. Aluminum Coated Steel Sheet: ASTM A463.

   f. Structural Bolts: ASTM F3125, Grade A325 or Grade A490.

   g. Bolts for Secondary Framing: ASTM A307.

   h. Tubing or Pipes for Structural Components: ASTM A500, Grade B.

   i. Anchor Rods: ASTM F1554, Grade 36.

   j. Steel Rods: ASTM A36

B. Welding Materials:

1. Type required for material being welded in conformance with AWS D1.1.

2.4 STRUCTURAL FRAMING COMPONENTS

A. Primary Framing: Shop fabricate framing components to indicate size and section with baseplates, bearing plates, stiffeners, and other items required for erection welded into place. Cut, form, punch, drill, and weld framing for bolted field assembly.

1. Make shop connections by welding or by using high-strength bolts.

2. Join flanges to webs of built-up members by a continuous submerged arc-welding process.

3. Brace compression flange of primary framing with steel angles, or cold-formed structural tubing between frame web and purlin or girt web, so flange compressive strength is within allowable limits for any combination of loadings.

4. Weld or bolt clips to frames for attaching secondary framing members.

5. Shop Priming: Prepare surfaces for shop priming according to SSPC-SP 2. Shop prime primary structural members with specified primer after fabrication.

B. Secondary Framing: Shop fabricate framing components to indicate size and section by roll-forming or break-forming, with baseplates, bearing plates, stiffeners and other plates required for erection welded into place. Cut, form, punch, drill, and weld secondary framing for bolted field connections to primary framing.

1. Make shop connections by welding or by using high-strength bolts.

2. Provide manufacturer’s standard secondary framing members, including purlins, girts, eave struts, flange bracing, sag bracing, base or sill members, gable angles, clips, headers, jambs, and other miscellaneous structural members. Fabricate framing from cold-formed, structural-steel sheet or roll-formed, metallic-coated steel sheet prepainted with coil coating, unless otherwise indicated.

C. Lateral Bracing Members: Provide adjustable lateral bracing as follows:

1. Rods: ASTM A36; ASTM A572, Grade 50; or ASTM A529, Grade 50; minimum 1/2-inch diameter steel; threaded a minimum of 6 inches on each end.

2. Rigid Portal Frames: Fabricate from shop-welded, built-up steel plates or structural-steel shapes to match primary framing; of size required to withstand design loads.

2.5 METAL PANEL MATERIAL FINISH

A. Approved finish is Star Building Systems Signature 300 Colors.

B. Comply with NAAMM’s “Metal Finishes Manual for Architectural and Metal Products” for recommendations for applying and designating finishes.

C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved samples and are assembled or installed to minimize contrast.

D. Metallic-Coated Steel Sheet Prepainted with Coil Coating: Steel sheet metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A755.

1. Sheet Steel Stock: Pre-finished, zinc-coated (galvanized) ASTM A653, structural quality, with a G90 coating.

2. Surface: Smooth, flat finish.

3. Exposed Finishes: Apply the following coil coating:

a. Interior Finish: Acrylic-Enamel Coating - Epoxy primer and acrylic-enamel topcoat; with a dry film thickness of not less than 0.2 mil for primer and 0.8 mil for topcoat.

b. Exterior Finish: Siliconized-Polyester Coating - Epoxy primer and silicone-modified, polyester-enamel topcoat; with a dry film thickness of not less than 0.2 mil for primer and 0.8 mil for topcoat.

4. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored backer finish, consisting of prime coat and wash coated with a total minimum dry film thickness of 0.5 mil.

2.6 ROOF PANEL SYSTEM:

A. Tapered-Rib-Profile, Lap-Seam Metal Roof Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced between major ribs; designed to be field assembled by lapping side edges of adjacent panels and mechanically attached panels to supports using exposed fasteners in side laps.

1. Color: Brownstone. Star Building Systems Commercial / Industrial Signature 300 Kynar 500 numbers SR. 47 SRI 54; verify with Owner.

2. Thickness: 26 GA.

3. Panel Coverage: 36 inches and maximum length to minimize end laps. End laps shall occur over secondary structural members and be sealed with tape mastic and non-skinning butyl caulk.

4. Panel Height: 1.25 inch or 1.5 inch.

5. Major-Rib Spacing: 12 inches on center.

2.7 WALL PANEL SYSTEM:

A. Tapered-Rib-Profile, Exposed-Fastener Metal Wall Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced between major ribs; designed to be field assembled by lapping side edges of adjacent panels and mechanically attached panels to supports using exposed fasteners in side laps.

1. Profile: Behlen ADP2 or approved equal.

2. Color: Brownstone. Star Building Systems Commercial / Industrial Signature 300 Kynar 500 numbers SR. 47 SRI 54; verify with Owner.

3. Thickness: 26 GA.

4. Panel Coverage: 36 inches and maximum length to minimize end laps. Minimum one panel for heights less than 30 feet.

5. Panel Height: 1.25 inch or 1.5 inch.

6. Major-Rib Spacing: 12 inches on center.

2.8 THERMAL INSULATION

A. Metal Building Insulation: ASTM C991, Type I, or NAIMA 202 glass-fiber-blanket insulation; 0.5-lbs/cu.ft. density; 2-inch-wide continuous, vapor-tight edges tabs; and with a flame-spread index of 25 or less.

B. Vapor-Retarder Facing: ASTM C1136, with permeance not greater than 0.02 perm when tested according to ASTM E96, Desiccant Method.

1. Composition: White vinyl film facing, fiberglass scrim reinforcement, and metallized-polyester film backing.

C. Retainer Strips: 0.019-inch thick, formed, galvanized steel or PVC retainer clips colored to match insulation facing.

D. Vapor-Retarder Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.

2.9 ACCESSORIES

A. General: Provide accessories as standard with metal building system manufacturer and as specified. Fabricate and finish accessories at the factory to the greatest extent possible by manufacturer's standard procedures and processes. Comply with indicated profiles and with dimensional and structural requirements.

1. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folder back to form hems.

B. Roof Panel Accessories: Provide components required for a complete metal roof panel assembly including copings, fasciae, corner units, ridge closures, clips, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal roof panels, unless otherwise indicated.

1. Closures: Provide closures at eaves and ridges, fabricated of same material as metal roof panels.

2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.

3. Closure Strips: Closed-cell, expanded, cellular, rubber or cross-linked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch thick, flexible closure strips; cut or premolded to match metal roof profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

4. Thermal Spacer Blocks: Where metal panels attach direction to purlins, provide thermal spacer blocks of thickness required to provide 1-inch standoff; fabricated from extruded polystyrene.

C. Wall Panel Accessories: Provide components required for a complete metal wall panel assembly including copings, fasciae, mullions, sills, corner units, clips, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal wall panels, unless otherwise indicated.

1. Closures: Provide closures at eaves and rakes, fabricated of same material as metal wall panels.

2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.

3. Closure Strips: Closed-cell, expanded cellular, rubber or cross-linked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch thick, flexible closure strips; cut or premolded to match metal wall panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

D. Flashing and Trim: Formed from minimum 0.0159-inch thick, metallic-coated steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating.

1. Color: Almond. Star Building Systems Commercial / Industrial Signature 300 Kynar 500 numbers SR. 63 SRI 76; verify with Owner.

2. Provide flashing and trim as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers.

3. Opening Trim: Minimum 0.0159 inch thick, metallic-coated steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating. Trim head and jamb of door openings, and head, jamb, and sill of other openings.

E. Gutters: Formed from minimum 0.0159-inch thick, zinc-coated (galvanized) steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating; finished to match roof fascia and rake trim. Match profile of gable trim, complete with end pieces, outlet tubes, and other special pieces as required. Fabricate in minimum 96-inch long sections, sized according to SMACNA's "Architectural Sheet Metal Manual."

1. Gutter Supports: Fabricated from same material and finish as gutter; spaced 36 inches on center.

2. Strainers: Bronze, copper, or aluminum wire ball type at outlets.

F. Downspouts: Formed from 0.0159-inch thick, zinc-coated (galvanized) steel sheet or aluminum-zinc alloy-coated steel sheet prepainted coil coating; finished to match metal wall panels. Fabricate in minimum 10-foot long sections, complete with formed elbows and offsets.

1. Mounting Straps: Fabricated from same material and finish as gutters; spaced 10 feet on center.

2.10 MISCELLANEOUS MATERIALS

A. Fasteners: Self-tapping screws, bolts, nuts, self-locking rivets and bolts, end-welded studs, and other suitable fasteners designed to withstand design loads. Provide fasteners with heads matching color of materials being fastened by means of plastic caps or factory-applied coating.

1. Fasteners for Metal Roof Panels: Self-drilling or self-tapping, zinc-plated, hex-head carbon-steel screws, with a stainless-steel cap or zinc-aluminum-alloy head and EPDM or neoprene sealing washer.

2. Fasteners for Metal Wall Panels: Self-drilling or self-tapping, zinc-plated, hex-head carbon-steel screws, with nylon or polypropylene washer.

3. Fasteners for Flashing and Trim: Blind fasteners or self-drilling screws with hex washer head.

B. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15-mil dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

C. Metal Panel Sealants:

1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape of manufacturer's standard size.

2. Joint Sealant: ASTM C920; one-part elastomeric polyurethane, polysulfide, or silicone-rubber sealant; of type, grade, class, and use classifications required to seal joints in metal panels and remain weathertight; and as recommended by metal building system manufacturer.

2.11 PAINTS AND PRIMERS

A. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:

1. SSPC-SP3, "Power Tool Cleaning."

B. Galvanizing:

1. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A 123.

a. Fill vent holds and grind smooth after galvanizing.

2. All framing members, nuts, bolts, and washers to be galvanized.

2.12 DOORS AND FRAMES

A. Materials:

1. Cold-Rolled Sheet Steel: ASTM A1008, Commercial Steel (CS), Type B, suitable for exposed applications.

2. Hot-Rolled Steel Sheet: ASTM A1011, Commercial Steel (CS), Type B, free of scale, pitting, or surface defects; pickled and oiled.

3. Metallic-Coated Steel Sheet: ASTM A653, Commercial Steel (CS), Type B; with G60 (Z180) zinc (galvanized) or A60 (ZF180) zinc-iron-alloy (galvannealed) coating designation.

B. Swinging Personnel Doors and Frames: Metal building system manufacturer's standard doors and frames; prepared and reinforced at strike and hinges to receive factor- and field-applied hardware according to ANSI/DHI A115 series.

1. Steel Doors: 1-3/4 inches thick; fabricated from 0.0329 inch uncoated thickness, metallic-coated steel face sheets; of styles indicated; seamless at both vertical edges; with 0.0528 inch uncoated thickness, inverted metallic-coated steel channels welded to face sheets at top and bottom of door.

   a. Core: Polyurethane foam with U-factor rating of at least 0.07 Btu/square feet x h x deg F.

   b. Glazing Frames: Steel frames to receive field-installed glass.

2. Glazing: Tempered Float Glass: ASTM C1048, Kind HS or FT, Condition A, Type 1, Quality-Q3, Class 1 (clear), 3 mm thick.

3. Steel Frames: Fabricate 2 inch wide face frames from 0.0528 inch uncoated thickness, metallic-coated steel sheet.

   a. Type: Factory welded.

4. Fabricate concealed stiffeners, reinforcement, edge channels, and moldings from either cold- or hot-rolled sheet.

5. Hardware:

   a. Provide hardware for each door leaf, as follows:

      1) Hinges: Three antifriction-bearing, standard weight, full-mortise, stainless-steel or bronze, template-type hinges; 4-1/2 by 4-1/2 inches, with nonremovable pin.

      2) Lockset: Mortise, with lever handle type.

      3) Panic Device: Touch-bar or push-bar type.

      4) Threshold: Extruded aluminum.

5) Silencers: Pneumatic rubber; three silences on strike jambs of single door frames and two silences on heads of double door frames.

6) Closer: Surface-applied, standard-duty, hydraulic type.

7) Weather Stripping: Vinyl applied to head and jambs, with vinyl sweep at sill.

6. Anchors and Accessories: Manufacturer's standard units, galvanized according to ASTM A123.

7. Fabrication: Fabricate doors and frames to be rigid; neat in appearance; and free from defects, warp, or buckle. Provide continuous welds on exposed joints; grind, dress, and make welds smooth, flush and invisible.

8. Finishes for Personnel Doors and Frames:

a. Surface Preparation: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it. Clean welds, mechanical connections and abraded areas, and apply galvanized repair paint specified below to comply with ASTM A780.

1) Galvanized Repair Paint: High-zinc-dust-content paint for regalvanizing welds in steel, complying with SSPC-Paint 20.

b. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply the primer specified below immediately after cleaning and pretreating.

1) Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI 250.10 acceptance criteria.

c. Color: Medium Bronze. Star Building Systems Commercial / Industrial Signature 300 Kynar 500 numbers SR. 33 SRI 36; verify with Owner.

C. Overhead Coiling Doors: Interlocking slats in a continuous length for width of door of thickness and mechanical properties recommended by door manufacturer for performance, size, and type of door.

1. Door size to fit door opening shown on drawings.

2. Doors shall have manual opening device.

3. Slats constructed of an exterior face of anodized aluminum and an interior face of rigid polyvinyl chloride and capped with nylon end caps. Slats to be filled and unitized with pour-type polyurethane foam having a "K" Factor of .12 at 75°F.

4. Doors to be fully weathersealed, with top seal to include headermounted brushes and bottom seal to include safety reversing edge.

5. Side guides to be lined with high density PVC to prevent metal-to-metal contact with slats. Curtain travel guide system with roller wheels will not be allowed.

6. Exterior and interior color to be Medium Bronze. Star Building Systems Commercial / Industrial Signature 300 Kynar 500 numbers SR. 33 SRI 36; verify with Owner.

2.13 WINDOWS

A. Aluminum Windows: Metal building system manufacturer's standard, with self-flashing mounting fins, and as follows:

1. Type, Performance Class, and Performance Grade: Comply with AAMA/NWWDA 101/I.S.2 and as follows:

   a. Fixed Units: F-LC25.

2. Aluminum Extrusions: ASTM B221, alloy and temper recommended by manufacturer for strength, corrosion resistance, and application of required finish, but not less than 0.062 inch thickness at any location for main frame and sash members.

   a. Thermally Improved Construction: Fabricate window units with an integral, concealed, low-conductance thermal barrier; located between exterior materials and window members exposed on interior side; in a manner that eliminates direct metal-to-metal contact.

3. Mullions: Between adjacent windows, fabricated of extruded aluminum matching finish of window units.

4. Fasteners, Anchors, and Clips: Aluminum, nonmagnetic stainless steel, or other noncorrosive material, compatible with aluminum window members, trim, hardware, anchors, and other components of window units. Fasteners shall not be exposed, except for attaching hardware.

   a. Reinforcement: Where fasteners screw-anchor into aluminum less than 0.125 inch thick, reinforce interior with aluminum or nonmagnetic stainless steel to receive screw threads, or provide standard, noncorrosive, pressed-in, splined grommet nuts.

5. Finish: Mill.

6. Baked-Enamel Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals). Apply baked enamel complying with paint manufacturer's written instructions for cleaning, conversion coating, and painting.

   a. Organic Coating: Thermosetting, modified-acrylic enamel primer/topcoat system complying with AAMA 2603 except with a minimum dry film thickness of 0.7 mil, medium gloss.

      1) Color: As indicated by manufacturer's designations.

B. Glazing:

1. Tempered Float Glass: ASTM C1048, Kind HS or FT, Condition A, Type 1, Quality-Q3, Class 1 (clear), 3 mm thick.

2. Glazing Stops: Screw-applied or snap-on glazing stops coordinated glazing system indicated. Match material and finish of window frames.

3. Factory-Glazed Fabrication: Glaze window units in the factory to greatest extent possible and practical for applications indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify site conditions.

B. Verify that foundations are positioned correctly and the anchor rods installed as indicated on the shop drawings.

C. For baseplates without grout, Concrete Contractor shall modify top of piers as required to get the concrete piers to the correct elevation. Contractor to submit modification procedures to Engineer of Record and metal building manufacturer for review.

3.2 INSTALLATION – EMBEDDED ITEMS

A. Anchor Rods:

1. All anchor rods are to be set by the Concrete Contractor and shall be furnished promptly so that they may be built in as the work progresses.

3.3 ERECTION

A. Bracing and Protection:

1. The erector and not the Structural Engineer of Record shall be responsible for the means, methods and safety of erection of the structural steel framing.

2. Erect metal building system according to manufacturer’s written erection instructions and erection drawings.

3. Erection of all structural steel items shall meet the requirements of AISC “Specification and Code of Standard Practice.”

4. Steel shall be well plumbed, leveled and braced to prevent any movement.

   a. Contractor shall provide and maintain all necessary temporary guying of steel frame to resist safely all wind and construction loads during erection and to assure proper alignment of all parts of the steel frame.

5. Provide all temporary bracing, shoring and guards necessary to prevent damage or injury. All partially erected metal shall be secured in an approved manner during interruptions of work.

B. Framing:

1. All work shall be erected square, plumb, straight and true, accurately fitted and with tight joints and intersections, by mechanics experienced in the erection of metal buildings. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.

2. Do not field cut or alter structural members without approval of Metal Building Engineer.

3. Steel erection shall not proceed without concrete in footings, piers, and walls attaining 75% of the intended minimum compressive design strength. Documentation must be provided indicating compliance with this requirement.

3.4 METAL PANEL INSTALLATION, GENERAL

A. Verify the structural panel support members and anchorages have been installed within alignment tolerances required by manufacturer.

1. Examine rough-in for components and systems penetrating metal panels to verify actual location of penetrations relative to seam locations of metal panels before metal panel installation.

B. Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Field cut metal panels as required for doors, windows, and other openings. Cut openings as small as possible, neatly to size required, and without damage to adjacent metal panel finishes.

2. Field cutting of metal panels by torch is not permitted.

3. Install metal panels perpendicular to structural supports, unless otherwise indicated.

4. Flash and seal metal panels with weather closures at perimeter of openings and similar elements. Fasten with self-tapping screws.

5. Locate and space fastenings in uniform vertical and horizontal alignment.

6. Locate metal panel splices over, but not attached to, structural supports with end laps in alignment. Stagger panel splices and end laps to avoid a four-panel lap splice condition.

7. Lap metal flashing over metal panels to allow moisture to run over and off the material.

C. Lap-Seam Metal Panels: Install screw fasteners with power tools controlled torque adjusted to compress neoprene washer tightly without damage to washer, screw threads, or metal panels. Install screws in predrilled holes.

1. Arrange and nest side-lap joints so prevailing winds blow over, not into, lapped joints. Lap ribbed or fluted sheets one full rib corrugations. Apply metal panels and associated items for neat and weathertight enclosure. Avoid “panel creep” or application not true to line.

D. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by metal roof panel manufacturer.

E. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal panel assemblies. Provide types of gaskets, fillers and sealants indicated or, if not indicated, types recommended by metal panel manufacturer.

1. Seal metal panel end laps with double beads of tape or sealant, full width of panel. Seal side joints where recommended by metal panel manufacturer.

2. Prepare joints and apply sealants to comply with requirements in Division 7 Section “Joint Sealants.”

3.5 METAL ROOF PANEL INSTALLATION

A. Provide metal roof panels of full length from eave to ridge, unless otherwise indicated or restricted by shipping limitations.

1. Install ridge caps as metal roof panel work proceeds.

2. Flash and seal metal roof panels with weather closures at eaves and rakes. Fasten with self-tapping screws.

B. Field-Assembled, Lap-Seam Metal Roof Panels: Fasten metal roof panels to supports with exposed fasteners at each lapped joint at location and spacing recommended by manufacturer.

1. Provide metal-backed washers under heads of exposed fasteners bearing on weather side of metal roof panels.

2. Provide sealant tape at lapped joints of metal roof panels and between panels and protruding equipment, vents, and accessories.

3. Apply a continuous ribbon of sealant tape to weather-side surface of fastenings on end laps and on side laps of nesting-type metal panels; on side laps of ribbed or fluted metal panels; and elsewhere as needed to make metal panels weatherproof to driving rains.

4. At metal panel splices, nest panels with minimum 6 inch end lap, sealed with butyl-rubber sealant and fasten together by interlocking clamping plates.

C. Metal Fascia Panels: Align bottom of metal panels and fasten with blind rivets, bolts, or self-tapping screws. Flash and seal metal panels with weather closures where fasciae meet soffits, along lower panel edges, and at perimeter of all openings.

D. Metal Roof Panel Installation Tolerances: Shim and align metal roof panels within installed tolerance of 1/4 inch in 20 feet on slope and location lines indicated and within 1/8 inch offset adjoining faces and of alignment of matching profiles.

3.6 METAL WALL PANEL INSTALLATION

A. Install metal wall panels in orientation, sizes, and locations indicated on drawings. Install panels perpendicular to girts, extending full height of building, unless otherwise indicated. Anchor metal wall panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Unless otherwise indicated, begin metal panel installation at corners, with center of rib lined up with line of framing.

2. Shim or otherwise plumb substrates receiving metal wall panels.

3. When two rows of metal panels are required, lap panels 4 inches minimum.

4. When building height requires two rows of metal panels at gable ends, align lap of gable panels over metal wall panels at eave height.

5. Rigidly fasten base end of metal wall panels and allow eave end free movement due to thermal expansion and contraction. Predrill panels.

6. Flash and seal metal wall panels with weather closures at eaves, rakes, and at perimeter of all openings. Fasten with self-tapping screws.

7. Install screw fasteners in predrilled holes.

8. Install flashings and trim as metal wall panel work proceeds.

9. Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete, and elsewhere as indicated, or if not indicated, as necessary for waterproofing.

10. Align bottom of metal wall panels and fasten with blind rivets, bolts, or self-tapping screws.

11. Provide weatherproof escutcheons for pipe and conduit penetrating exterior walls.

B. Field-Assembled, Metal Wall Panels: Install metal wall panels on exterior side of girts. Attach metal wall panels to supports with fasteners as recommended by manufacturer.

1. Field-Insulated Assemblies: Install thermal insulation as specified. Install metal liner panels over insulation on interior side of girts at locations indicated. Fasten with exposed fasteners as recommended by manufacturer.

C. Factory-Assembled, Insulated Metal Wall Panels: Install insulated metal wall panels on exterior side of girts. Attach panels to supports at each panel joint with concealed clip and fasteners at 42 inches on center, but spaced not more than as recommended by manufacturer. Fully engage tongue and groove of adjacent insulated metal wall panels.

1. Install clips to supports with self-tapping fasteners.

2. Apply continuous ribbon of sealant to panel joint on concealed side of insulated metal wall panels as vapor seal; apply sealant to panel joint on exposed side of panels for weather seal.

D. Installation Tolerances: Shim and align metal walls panels within installed tolerance of 1/4 inch in 20 feet, noncumulative, on level, plumb, and location lines indicated and within 1/8 inch offset adjoining faces and of alignment of matching profiles.

3.7 THERMAL INSULATION INSTALLATION FOR FIELD-ASSEMBLED METAL PANELS

A. Install insulation concurrently with metal wall panel installation, in thickness indicated to cover entire wall, according to manufacturer’s written instructions.

1. Set vapor-retarder-faced units with vapor retarder to warm side of construction, unless otherwise indicated. Do not obstruct ventilation spaces, except for firestopping.

2. Tape joints and ruptures in vapor retarder, and seal each continuous area of insulation to surrounding construction to ensure airtight insulation.

3. Install factory-laminated, vapor-retarder-faced blankets straight and true in one-piece lengths, with both sets of facing tabs sealed to provide a complete vapor retarder.

4. Protect insulation from getting wet. Remove and replace water-logged insulation at Contractor’s expense.

5. Install blankets straight and true in one-piece lengths. Install vapor retarder over insulation with both sets of facing tabs sealed to provide a complete vapor retarder.

B. Blanket Roof Insulation: Comply with the following installation method:

1. Over-Purlin-with-Spacer-Block Installation: Extend insulation and vapor retarder over and perpendicular to top flange of secondary framing members. Install layer of filler insulation over first layer to fill space formed by metal roof panel standoffs. Hold in place by panels fastened to standoffs.

2. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with secondary framing to hold insulation in place.

3. Thermal Spacer Blocks: Where metal roof panels attach directly to purlins, install thermal spacer blocks.

C. Blanket Wall Insulation: Extend insulation and vapor retarder over and perpendicular to top flange of secondary framing members. Hold in place by metal wall panels fastened to secondary framing:

1. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with secondary framing to hold insulation in place.

2. Sound-Absorption Insulation: Where sound-absorption requirement is indicated for metal liner panels, cover insulation with polyethylene film and provide inserts of wire mesh to form acoustical spacer grid.

3.8 DOOR AND FRAME INSTALLATION

A. Install doors and frames plumb, rigid, properly aligned, and securely fastened in place according to manufacturer's written instructions. Coordinate installation with wall flashings and other components. Seal perimeter of each door frame with elastomeric sealant used for metal wall panels.

B. Personnel Doors and Frames: Install doors and frames according to ANSI A250.8. Shim as necessary to comply with DHI A115.IG. Fit non-fire-rated doors accurately in their respective frames, with the following clearances:

1. Between Doors and Frames at Jamb and Head: 1/8 inch.
2. Between Edges of Pair of Doors: 1/8 inch.
3. At Door Sills with Threshold: 3/8 inch.
4. At Door Sills without Threshold: 3/4 inch.

C. Coiling Doors:

1. Install coiling doors and operating equipment complete with necessary hardware, jamb and head molding strips, anchors, inserts, hangers, and equipment supports.

2. Lubricate bearings and sliding parts; adjust doors to operate easily, free of warp, twist, or distortion, and with weathertight fit around entire perimeter.

D. Door Hardware: Mount units at heights indicated in DHI's "Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames."

1. Install surface-mounted items after finishes have been completed on substrates involved.

2. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.

3. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.

4. Set thresholds for exterior doors in full bed of butyl-rubber or polyisobutylene mastic sealant.

3.9 WINDOW INSTALLATION

A. Install windows plumb, rigid, properly aligned, without warp or rack or frames or sash, and securely fastened in place according to manufacturer's written instructions. Coordinate installation with wall flashings and other components. Seal perimeter of each window frame with elastomeric sealant used for metal wall panels.

1. Separate dissimilar materials from sources of corrosion or electrolytic action at points of contact with other materials by complying with requirements specified in "Dissimilar Materials" Paragraph in Appendix B in AAMA/NWWDA 101/I.S.2.

B. Set sill members in bed of sealant or with gaskets, as indicated, for weathertight construction.

C. Install windows and components to drain condensation, water penetrating joints, and moisture migrating within windows to the exterior.

D. Mount screens direct to frames with tapped screw clips.

3.10 ACCESSORY INSTALLATION

A. Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal roof panel assembly including trim, copings, ridge closures, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.

2. Install components for a complete metal wall panel assembly including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure, strips, and similar items.

3. Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by manufacturer.

B. Flashing and Trim: Comply with performance requirements, manufacturer’s written installations, and SMACNA’s “Architectural Sheet Metal Manual.” Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

1. Install exposed flashing and trim that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.

2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet, with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).

C. Gutters: Join sections with riveted and soldered or lapped and sealed joints. Attach gutters to eave with gutter hangers spaced not more than 4 feet on center using manufacturer’s standard fasteners. Provide end closures and seal watertight with sealant. Provide for thermal expansion.

D. Downspouts: Join sections with 1-1/2 inch telescoping joints. Provide fasteners designed to hold downspouts securely 1 inch away from walls; locate fasteners at top and bottom at approximately 60 inches on center in between.

1. Provide elbows at base of downspouts to direct water away from building.

3.11 ADJUSTING

A. Doors: After completing installation, test and adjust doors to operate easily, free of warp, twist, or distortion.

B. Door Hardware: Adjust and check each operating item of door hardware and each door to ensure proper operation and function of every unit. Replace units that cannot be adjusted to operate as intended.

1. Door Closures: Adjust door closers to compensate for final operation of heating and ventilating equipment. Adjust sweep period so that, from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3 inches from the latch, measured to the leading edge of the door.

3.12 CLEANING, REPAIRS, PROTECTION, AND TOUCHUP

A. Touchup Painting: After installation, promptly clean, prepare, and prime or reprime field welds, final connections, rust spots, and abraded surfaces of prime-painted structural framing and accessories.

1. Clean and prepare surfaces by SSPC-SP2 hand-tool cleaning or SSPC-SP3 power-tool cleaning.

2. Apply a compatible primer of the same type as shop primer used on adjacent surfaces.

B. Metal Panels: Replace temporary protective coverings and strippable films, if any, as metal panels are installed. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in clean condition during construction.

1. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

C. Doors and Frames: Immediately after installation, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying primer.

1. Immediately before final inspection, remove protective wrappings from doors and frames.

D. Windows: Clean metal surfaces immediately after installing windows. Avoid damaging protective coatings and finishes. Remove excess sealants, glazing materials, dirt, and other substances. Clean factory-glazed glass immediately after installing windows.

E. Remove and replace glass that has been broken, chipped, cracked, abraded, or damaged during construction period.

3.13 COLOR SCHEDULE

A. Exterior Wall and Roof Panels: Brownstone. Star Building Systems Commercial / Industrial Signature 300 Kynar 500 numbers SR. 47 SRI 54; verify with Owner.

B. Corner Trim, Rake Trim, Eave Trim, and Gutters: Almond. Star Building Systems Commercial / Industrial Signature 300 Kynar 500 numbers SR. 63 SRI 76; verify with Owner.

C. Doors: Medium Bronze. Star Building Systems Commercial / Industrial Signature 300 Kynar 500 numbers SR. 33 SRI 36; verify with Owner.

D. Color Formulations: Available upon request.

END OF SECTION

SECTION 23 05 00

BASIC HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 23 Sections. Also refer to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 REFERENCES

A. This Specification and the associated drawings govern the furnishing, installing, testing and placing into satisfactory operation the Mechanical Systems.

B. Each Contractor shall provide all new materials indicated on the drawings and/or in these specifications, and all items required to make his portion of the Mechanical Work a finished and working system.

C. All work will be awarded under a single General Contract. The division of work listed below is for the Contractor's convenience and lists normal breakdown of the work.

D. Scope of Work:

1. Plumbing Work shall include, but is not necessarily limited to:

   a. Furnish and install all items listed in the Plumbing Material List.

   b. Furnish and install gas piping system including all meter requirements.

   c. Furnish and install a new fire protection service to the building including backflow preventer as required by Code.

   d. Furnish and install all fire hydrants and associated piping, valves, and supports including connection to the water main.

   e. Furnish and install makeup water connection to hydronic heating and/or cooling systems including reduced pressure principle type backflow preventer.

2. Air Conditioning and Ventilating Work shall include, but is not necessarily limited to:

   a. Furnish and install air-cooled condensing units and curbs.

   b. Furnish and install complete supply air ductwork systems including all fittings, insulation, and outlets.

   c. Furnish and install complete return air ductwork systems including all fittings, insulation, and inlets.

d. Furnish and install mechanical room ventilation systems including louvers, ductwork, insulation, and fans.

e. Furnish and install all temperature control systems.

f. Furnish and install firestopping systems for penetrations of fire-rated construction associated with this Contractor's work.

3. Temperature Control Work shall include, but is not necessarily limited to:

a. Furnish and install a complete temperature control system as specified in Section 23 09 00.

b. Temperature control system shall consist of a full Direct Digital Control (DDC) system including all accessories, sensors, and programming.

c. Furnish and install firestopping systems for penetrations of fire-rated construction associated with this Contractor's work.

4. Testing, Adjusting, and Balancing Work shall include, but is not necessarily limited to:

a. Furnish complete testing, adjusting, and balancing as specified in Section 23 05 93, including, but not limited to, air systems, hydronic systems.

1.3 OWNER FURNISHED PRODUCTS

A. The Owner will supply the following items for installation and/or connection by This Contractor:

B. The following items shall be relocated, installed and/or connected by This Contractor:

C. The Owner will supply manufacturer's installation data for Owner-purchased equipment for this project.

D. This Contractor shall make all mechanical system connections shown on the drawings **or** as required for fully functional units.

E. This Contractor is responsible for all damage to Owner furnished equipment caused during installation.

1.4 WORK SEQUENCE

A. All work that will produce excessive noise or interference with normal building operations, as determined by the Owner, shall be scheduled with the Owner. It may be necessary to schedule such work during unoccupied hours. The Owner reserves the right to determine when restricted construction hours will be required.

B. Schedule overtime for the following work:

C. Itemize all work and list associated hours and pay scale for each item.

1.5 ALTERNATES

A. Refer to drawings for identification of bid alternates.

1.6 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL & CONTROL CONTRACTORS

A. Definitions:

1. "Mechanical Contractors" refers to the following:

   a. Plumbing Contractor.
   b. Heating Contractor.
   c. Air Conditioning and Ventilating Contractor.
   d. Temperature Control Contractor.
   e. Testing, Adjusting, and Balancing Contractor.

2. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case the devices are usually single phase and are usually connected to the motor power wiring through a manual motor starter having "Manual-Off-Auto" provisions.

3. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.

4. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. Generally, where the motor power wiring exceeds 120 volts, a control transformer is used to give a control voltage of 120 volts.

5. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring which directly powers or controls a motor used to drive equipment such as fans, pumps, etc.

   a. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt) in which case a control transformer shall be furnished as part of the temperature control wiring.

6. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.

B. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractor's responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors and the like. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals reviewed.

Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.

2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall provide complete wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.

3. All electrical work shall conform to the National Electrical Code. All provisions of the Electrical Specifications concerning wiring, protection, etc., apply to wiring provided by the Mechanical Contractor unless noted otherwise.

4. Control low (24V) and control line (120V) voltage wiring, conduit, and related switches and relays required for the automatic control and/or interlock of motors and equipment, including final connection, are to be furnished and installed under Divisions 21, 22 and 23. Materials and installation to conform to Class 1 or 2 requirements, California Code of Regulation Title 24, Article E725.

5. All Contractors shall establish utility elevations prior to fabrication and shall coordinate their material and equipment with other trades. When a conflict arises, priority is as follows:

   a. Light fixtures.
   b. Gravity flow piping, including steam and condensate.
   c. Electrical busduct.
   d. Sheet metal.
   e. Electrical cable trays, including access space.
   f. Sprinkler piping and other piping.
   g. Electrical conduits and wireway.

C. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment provided by the Mechanical Contractor, for example:

   a. Computer Room Air Conditioning Units.
   b. Condensing Units.
   c. Makeup Air Units.
   d. Gas Trains.

2. Assumes all responsibility for the Temperature Control wiring, when the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.

3. Temperature Control Subcontractor's Responsibility:

   a. Wiring of all devices needed to make the Temperature Control System functional.

   b. Verifying any control wiring on the electrical drawings as being by the Electrical Contractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Subcontractor.

c. Coordinating equipment locations (such as relays, transformers, etc.) with the Electrical Contractor, where wiring of the equipment is by the Electrical Contractor.

4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

D. Electrical Contractor's Responsibility:

1. Provides all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor on the Mechanical Drawings or Specifications.

2. Installs and wires all remote control devices furnished by the Mechanical Contractor or Temperature Control Subcontractor when so noted on the Electrical Drawings.

3. Provides motor control and temperature control wiring, where so noted on the drawings.

4. Coordinate with the Mechanical Contractor for size of motors and/or other electrical devices involved with repair or replacement of existing equipment.

5. Furnishes, installs and connects all relays, etc., for automatic shutdown of certain fans upon actuation of the Fire Alarm System as indicated and specified in Division 28.

6. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.7 QUALITY ASSURANCE

A. Contractor’s Responsibility Prior to Submitting Pricing Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guidelines, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the individual Contract Documents and report at once in writing to the Design Team any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.

2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor’s own employees. Any work performed prior to receipt of instructions from the Design Team will be done at the Contractor’s risk.

B. Qualifications:

1. Only products of reputable manufacturers are acceptable.

2. All Contractors and subcontractors shall employ only workers skilled in their trades.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the State of Wisconsin Codes, Laws, Ordinances and other regulations having jurisdiction.

2. Conform to all State Codes.

3. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.

4. If the Contractor notes, at the time of bidding, any parts of the drawings or specifications that do not comply with the codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, he shall submit with his proposal a separate price to make the system comply with the codes and regulations.

5. All changes to the system made after letting of the contract, to comply with codes or requirements of Inspectors, shall be made by the Contractor without cost to the Owner.

6. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.

7. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.

3. Pay all charges for permits or licenses.

4. Pay all fees and taxes imposed by the State, Municipal and/or other regulatory bodies.

5. Pay all charges arising out of required inspections by an authorized body.

6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.

7. Where applicable, all fixtures, equipment and materials shall be approved or listed by Underwriter’s Laboratories, Inc.

E. Utility Company Requirements:

1. Secure from the appropriate private or public utility company all applicable requirements.

2. Comply with all utility company requirements.

3. Make application for and pay for service connections, such as gas.

4. Make application for and pay for all meters and metering systems required by the utility company.

F. Examination of Drawings:

1. The drawings for the mechanical work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.

2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of pipes and ducts to best fit the layout of the job.

3. Scaling of the drawings is not sufficient or accurate for determining these locations.

4. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

5. Because of the scale of the drawings, certain basic items, such as fittings, boxes, valves, unions, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.

6. If an item is either on the drawings or in the specifications, it shall be included in this contract.

7. Determination of quantities of material and equipment required shall be made by the Contractor from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater number shall govern.

8. Where used in mechanical documents, the word "furnish" shall mean supply for use, the word "install" shall mean connect complete and ready for operation, and the word "provide" shall mean to supply for use and connect complete and ready for operation.

   a. Any item listed as furnished shall also be installed, unless otherwise noted.

   b. Any item listed as installed shall also be furnished, unless otherwise noted.

G. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any materials or fabricating any supports, pipes or ducts.

H. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed “Electronic File Transmittal” form provided by IMEG.

4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor’s use of these documents.

1.8 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	Submittal Item
23 05 00	Owner Training Agenda
23 05 13	Motors
23 05 15	Variable Frequency Drives
23 05 48	Vibration Isolation Equipment
23 05 93	Testing, Adjusting, and Balancing
23 34 13	Axial Fans
23 34 16	Centrifugal Fans
23 34 23	Power Ventilators
23 74 23.13	Gas Fired Make-up Air Units
23 81 45	Variable Refrigerant Flow Heat Pumps

Referenced Specification Section	Submittal Item
23 82 00	Terminal Heat Transfer Equipment

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

   a. Date
   b. Project title and number
   c. Contractor's name and address
   d. Division of work (e.g., plumbing, heating, ventilating, etc.)
   e. Description of items submitted and relevant specification number
   f. Notations of deviations from the contract documents
   g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

   a. Date
   b. Project title and number
   c. Architect/Engineer
   d. Contractor and subcontractors' names and addresses
   e. Supplier and manufacturer's names and addresses
   f. Division of work (e.g., plumbing, heating, ventilating, etc.)
   g. Description of item submitted (using project nomenclature) and relevant specification number
   h. Notations of deviations from the contract documents
   i. Other pertinent data
   j. Provide space for Contractor's review stamps

3. Composition:

   a. Submittals shall be submitted using specification sections and the project nomenclature for each item.

   b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).

   c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

5. Contractor’s Approval Stamp:

   a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.

   b. Unstamped submittals will be rejected.

   c. The Contractor’s review shall include, but not be limited to, verification of the following:

      1) Only approved manufacturers are used.
      2) Addenda items have been incorporated.
      3) Catalog numbers and options match those specified.
      4) Performance data matches that specified.
      5) Electrical characteristics and loads match those specified.
      6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
      7) Dimensions and service clearances are suitable for the intended location.
      8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
      9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

   d. The Contractor shall review, stamp and approve all subcontractors’ submittals as described above.

   e. **The Contractor’s approval stamp is required on all submittals. Approval will indicate the Contractor’s review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.**

6. Submittal Identification and Markings:

   a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.

   b. The Contractor shall clearly indicate the size, finish, material, etc.

   c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.

   d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.

8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.

9. Reproduction of contract documents alone is not acceptable for submittals.

10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.

11. Submittals not required by the contract documents may be returned without review.

12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.

13. Submittals shall be reviewed and approved by the Architect/Engineer **before** releasing any equipment for manufacture or shipment.

14. Contractor’s responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer’s approval.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. Submittal file name: 23 XX XX.description.YYYYMMDD
   b. Transmittal file name: 23 XX XX.description.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be transmitted via a pre-approved method.

D. Paper Copy Submittal Procedures:

1. Paper copies are acceptable where electronic copies are not provided.

2. The Contractor shall submit ten (10) paper copies of each shop drawing.

3. Each set shall be bound in a three-ring binder or presentation binder. Copies that are loose or in pocket folders are not acceptable.

1.9 CHANGE ORDERS

A. A detailed material and labor takeoff shall be prepared for each change order, along with labor rates and markup percentages. Change orders with inadequate breakdown will be rejected.

B. Change order work shall not proceed until authorized.

1.10 EQUIPMENT SUPPLIERS' INSPECTION

A. The following equipment shall not be placed in operation until a competent installation and service representative of the manufacturer has inspected the installation and certified that the equipment is properly installed, adjusted and lubricated; that preliminary operating instructions have been given; and that the equipment is ready for operation:

1. Air Cooled Condensers
2. Boilers, Burners and Boiler Trim
3. Computer Room Units
4. Condensing Units
5. Gas Fired Makeup Air Units

B. Contractor shall arrange for and obtain supplier's on-site inspection(s) at proper time(s) to assure each phase of equipment installation and/or connection is in accordance with the manufacturer's instructions.

C. Submit copies of start-up reports to the Architect/Engineer and include copies of Owner’s Operation and Maintenance Manuals.

1.11 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage. Keep materials clean, dry and free from harmful conditions. Immediately remove any materials that become wet or that are suspected of becoming contaminated with mold or other organisms.

B. Keep all bearings properly lubricated and all belts properly tensioned and aligned.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Mechanical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate his/her work with other trades.

1.12 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.13 WARRANTY

A. Provide one-year warranty, unless otherwise noted, to the Owner for all fixtures, equipment, materials, and workmanship.

B. The warranty period for all work in this Division of the specifications shall commence on the date of final acceptance, unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner.

C. Warranty requirements shall extend to correction, without cost to the Owner, of all Work found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from defects or nonconformance with contract documents.

1.14 INSURANCE

A. Contractor shall maintain insurance coverage as set forth in Division 0 of these specifications.

1.15 CONTINGENCY

A. The Mechanical Contractors shall include in the Base Bid a contingency of one percent (1%) to be used only by change orders issued by the Architect/Engineer. The unused portion of the contingency shall be deducted from the Contract price before final payment is made.

1.16 MATERIAL SUBSTITUTION

A. Where several manufacturers' names are given, the manufacturer for which a catalog number is given is the basis for job design and establishes the quality required.

B. Equivalent equipment manufactured by the other named manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meet all requirements of the drawings and specifications, and fits in the allocated space.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer not later than ten days prior to the bid opening.

D. This Contractor assumes all costs incurred as a result of using the offered material, article or equipment, on his part or on the part of other Contractors whose work is affected.

E. This Contractor may list voluntary add or deduct prices for alternate materials on the bid form. These items will not be used in determining the low bidder.

F. All material substitutions requested later than ten (10) days prior to bid opening must be listed as voluntary changes on the bid form.

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or his or her employee and subconsultants at a construction site, shall relieve the Contractor and other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 ARCHITECT/ENGINEER OBSERVATION OF WORK

A. The Contractor shall provide seven (7) calendar days' notice to the Architect/Engineer prior to:

1. Placing fill over underground and underslab utilities.
2. Covering exterior walls, interior partitions and chases.
3. Installing hard or suspended ceilings and soffits.

B. The Architect/Engineer will have the opportunity to review the installation and provide a written report noting deficiencies requiring correction. The Contractor's schedule shall account for these reviews and show them as line items in the approved schedule.

3.3 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. In order to prevent the Final Jobsite Observation from occurring too early, the Contractor is required to review the completion status of the project and certify that the job is ready for the final jobsite observation.

2. Attached to the end of this section is a typical list of items that represent the degree of job completeness expected prior to requesting a review.

3. Upon Contractor certification that the project is complete and ready for a final observation, the Contractor shall sign the attached certification and return it to the Architect/Engineer so that the final observation can be scheduled.

4. It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineer's additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

C. Before final payment is authorized, this Contractor must submit the following:

1. Operation and maintenance manuals with copies of approved shop drawings.

2. Record documents including marked-up or reproducible drawings and specifications.

3. A report documenting the instructions given to the Owner's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representatives.

4. Inspection by State Boiler Inspector.

5. Start-up reports on all equipment requiring a factory installation inspection or start-up.

6. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to and place in location as directed; receipt by Architect/Engineer required prior to final payment approval.

3.4 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.

2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. O&M file name: O&M.div23.contractor.YYYYMMDD
   b. Transmittal file name: O&Mtransmittal.div23.contractor.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be divided into files that are clearly labeled as “1 of 2”, “2 of 2”, etc.

6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title “Operation and Maintenance Instructions”, title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.

7. All text shall be searchable.

8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Paper Copy Submittal Procedures:

1. Once the electronic version of the manuals has been approved by the Architect/Engineer, ______ paper copies of the O&M manual shall be provided to the Owner. The content of the paper copies shall be identical to the corrected electronic copy.

2. Binder Requirements: The Contractor shall submit O&M manuals in heavy duty, locking three ring binders. Incorporate clear vinyl sheet sleeves on the front cover and spine for slip-in labeling. “Peel and stick” labels are **not** acceptable. Sheet lifters shall be supplied at the front of each notebook. The three-ring binders shall be 1/2" thicker than initial material to allow for future inserts. If more than one notebook is required, label in consecutive order. For example; 1 of 2, 2 of 2. No other form of binding is acceptable.

3. Binder Labels: Label the front and spine of each binder with “Operation and Maintenance Instructions”, title of project, and subject matter.

4. Index Tabs: Divide information by specification section, major equipment, or systems using index tabs. All tab titling shall be clearly printed under reinforced plastic tabs. All equipment shall be labeled to match the identification in the construction documents.

D. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.

2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.

3. Copies of all final approved shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.

4. Refer to Section 23 09 00 for additional requirements for Temperature Control submittals.

5. Copy of final approved test and balance reports.

6. Copies of all factory inspections and/or equipment startup reports.

7. Copies of warranties.

8. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.

9. Dimensional drawings of equipment.

10. Capacities and utility consumption of equipment.

11. Detailed parts lists with lists of suppliers.

12. Operating procedures for each system.

13. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.

14. Repair procedures for major components.

15. List of lubricants in all equipment and recommended frequency of lubrication.

16. Instruction books, cards, and manuals furnished with the equipment.

3.5 INSTRUCTING THE OWNER'S REPRESENTATIVES

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of all systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. Contractor shall make a DVD video recording of instructions to the Owner while explaining the system so additional personnel may view the instructions at a later date. The video recording shall be the property of the Owner.

D. The instructions shall include:

1. Explanation of all system flow diagrams.
2. Explanation of all air handling systems.
3. Temperature control system operation including calibration, adjustment and proper operating conditions of all sensors.
4. Maintenance of equipment.
5. Smoke control systems.
6. Stairwell pressurization systems.
7. Start-up procedures for all major equipment.
8. Explanation of seasonal system changes.
9. Description of emergency system operation.

E. The Architect/Engineer shall be notified of the time and place instructions will be given to the Owner's representatives so he or his representative can attend if desired.

F. Minimum hours of instruction for each item shall be:

1. Heat Pump System - 4 hours.
2. Exhaust Systems - 2 hours.
3. Temperature Controls - As defined in Section 23 09 00.

G. The Contractor shall prepare a detailed, written training agenda and submit it to the Architect/Engineer a minimum of two weeks prior to the formal training for approval. The written agenda shall include specific training points within the items described above. For example: how to adjust setpoints, troubleshooting, proper start-up, proper shut-down, seasonal changes, draining, venting, changing filters, changing belts, etc. Failure to provide and follow an approved training agenda may result in additional training required at the expense of the Contractor.

H. Operating Instructions:

1. Contractor is responsible for all instructions to the Owner's representatives for the mechanical and control systems.

2. If the Contractor does not have staff that can adequately provide the required instructions he shall include in his bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.6 SYSTEM STARTING AND ADJUSTING

A. The mechanical systems shall be complete and operating. System startup, testing, adjusting, and balancing to obtain satisfactory system performance is the responsibility of the Contractor. This includes calibration and adjustments of all controls, noise level adjustments and final comfort adjustments as required.

B. Complete all manufacturer-recommended startup procedures and checklists to verify proper motor rotation, electrical power voltage is within equipment limitations, equipment controls maintain pressures and temperatures within acceptable ranges, all filters and protective guards are in-place, acceptable access is provided for maintenance and servicing, and equipment operation does not pose a danger to personnel or property.

C. Operate all HVAC systems continuously for at least one week prior to occupancy to bring construction materials to suitable moisture levels. Areas with mechanical cooling shall be maintained below 60% RH.

D. Contractor shall adjust the mechanical systems and controls at season changes during the one year warranty period, as required, to provide satisfactory operation and to prove performance of all systems in all seasons.

E. All operating conditions and control sequences shall be tested during the start-up period. Test all interlocks, safety shutdowns, controls, and alarms.

F. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.7 RECORD DOCUMENTS

A. The following paragraph supplements Division 1 requirements:

Contractor shall maintain at the job site a separate and complete set of mechanical drawings and specifications on which he shall clearly and permanently mark in complete detail all changes made to the mechanical systems.

B. Mark drawings to indicate revisions to piping and ductwork, size and location, both exterior and interior; including locations of coils, dampers, other control devices, filters, and other units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned from column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (e.g., traps, strainers, expansion compensators, tanks, etc.); Change Orders; concealed control system devices.

C. Refer to Section 23 09 00 for additional requirements for Temperature Control documents.

D. Before completion of the project, a set of reproducible mechanical drawings will be given to the Contractor for transfer of all as-built conditions from the paper set maintained at the job site. All marks on reproducibles shall be clear and permanent.

E. Mark specifications to show approved substitutions; Change Orders, and actual equipment and materials used.

F. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

G. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

3.8 PAINTING

A. This Contractor shall paint the following items:

B. Paint all equipment that is marred or damaged prior to the Owner's acceptance. Paint and color shall match original equipment paint and shall be obtained from the equipment supplier if available.

C. Equipment in finished areas that will be painted to match the room decor will be painted by others. Should this Contractor install equipment in a finished area after the area has been painted, he shall have the equipment and all its supports, hangers, etc., painted to match the room decor.

D. Equipment cabinets, casings, covers, metal jackets, etc., in equipment rooms or concealed spaces, shall be furnished in standard or prime finish, free from scratches, abrasions, chips, etc.

E. Equipment in occupied spaces, or if standard to the unit, shall have a baked primer with baked enamel finish coat free from scratches, abrasions, chips, etc. If color option is specified or is standard to the unit, this Contractor shall, before ordering, verify with the Architect/Engineer his color preference and furnish this color.

F. Paint all equipment in unfinished areas such as boiler room, mechanical spaces, storage room, etc., furnished by this Contractor. Equipment furnished with a factory coat of paint and enamel need not be painted, provided the factory applied finish is not marred or spattered. If so, equipment shall be refinished with the same paint as was factory applied.

G. Paint all outdoor uninsulated steel piping the color selected by Owner or Architect/Engineer.

H. After surfaces have been thoroughly cleaned and are free of oil, dirt, and other foreign matter; paint all pipes and equipment with the following:

1. <u>Bare Metal Surfaces</u> - Apply one coat of primer suitable for the metal being painted. Finish with two coats of Alkyd base enamel paint.

2. <u>Insulated Surfaces</u> - Paint insulation jackets with two coats of semi-gloss acrylic latex paint.

3.9 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project. Clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from all equipment.

B. Clean all drain pans and areas where moisture is present. Immediately report any mold, biological growth, or water damage.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

END OF SECTION

READINESS CERTIFICATION PRIOR TO FINAL JOBSITE OBSERVATION

To prevent the final job observation from occurring too early, we require that the Contractor review the completion status of the project and, by copy of this document, certify that the job is indeed ready for the final job observation. The following is a typical list of items that represent the degree of job completeness expected prior to your requesting a final job observation.

1. Penetrations fire sealed and labeled in accordance with specifications.
2. All air handling units operating and balanced.
3. All fans shall be operating and balanced.
4. All pumps, boilers and chillers operating and balanced.
5. All miscellaneous mechanical systems (unit heaters, fan coil units, cabinet heaters, etc.) operating.
6. All temperature control systems operating, programmed and calibrated.
7. Pipe insulation complete, pipes labeled and valves tagged.
8. Fire damper and fire/smoke damper access doors labeled in accordance with specifications.

Accepted by:

Prime Contractor ____

By ___________________________________ Date ___________________

Upon Contractor certification that the project is complete and ready for a final job observation, we require the Contractor to sign this agreement and return it to the Architect/Engineer so that the final observation can be scheduled.

It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineers for additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

* * * * *

SECTION 23 05 13

MOTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Single Phase and Three Phase Electric Motors.

1.2 REFERENCES

A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
C. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.
D. ANSI/IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators.
E. ANSI/NEMA MG 1 - Motors and Generators.
F. ANSI/NFPA 70 - National Electrical Code.
G. Energy Independence and Security Act of 2007.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00. Include nominal efficiency and power factor for all premium efficiency motors. Efficiencies must meet or exceed the nominal energy efficiency levels presented below.

B. Submit shop drawings for all three phase motors.

C. Submit motor data with equipment when motor is installed by the manufacturer at the factory.

D. Submit shaft grounding device for all motors as required.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof coverings. For extended outdoor storage, follow manufacturer's recommendations for equipment and motor.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data including assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in the manufacture of commercial and industrial motors and accessories, with a minimum of three years documented manufacturing experience.

PART 2 - PRODUCTS

2.1 MOTORS - GENERAL CONSTRUCTION AND REQUIREMENTS

A. Refer to the drawings for required electrical characteristics.

B. Design motors for continuous operation in 40ºC environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.

C. Explosion-Proof Motors: UL listed and labeled for the hazard classification shown on the drawing, with over-temperature protection.

D. Visible Nameplate: Indicating horsepower, voltage, phase, hertz, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, insulation class.

E. Electrical Connection: Boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

F. Unless otherwise indicated, motors 3/4 HP and smaller shall be single phase, 60 hertz, open drip-proof or totally enclosed fan-cooled type.

G. Unless otherwise indicated, motors 1 HP and larger shall be three phase, 60 hertz, squirrel cage type, NEMA Design Code B (low current in-rush, normal starting torque), open drip-proof or totally enclosed fan-cooled type.

H. Each contractor shall set all motors furnished by him.

I. All motors shall have a minimum service factor of 1.15.

J. All motors shall have ball or roller bearings with a minimum L-10 fatigue life of 150,000 hours in direct-coupled applications and 50,000 hours for belted applications. Belted rating shall be based on radial loads and pulley sizes called out in NEMA MG1-14.43.

K. Bearings shall be sealed type for 10 HP and smaller motors. Bearings shall be regreasable type for larger motors.

L. Aluminum end housings are not permitted on motors 15 HP or larger.

M. Provide all belted motors with a means of moving and securing the motor to tighten belts. Motors over 2 HP shall have screw type tension adjustment. Motors over 40 HP shall have dual screw adjusters. Slide bases shall conform to NEMA standards.

N. Motors for fans and pumps 1/12 HP or greater and less than 1 HP shall be electronically-commutated motors or shall have a minimum motor efficiency of 70% when rated in accordance with DOE 10 CFR 431. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans may use sheave adjustments for airflow balancing in lieu of varying motor speed.

2.2 PREMIUM EFFICIENCY MOTORS (INCLUDING MOST 3-PHASE GENERAL PURPOSE MOTORS)

A. All motors, unless exempted by EPAct legislation that became federal law on December 19, 2010, shall comply with the efficiencies listed in that standard, which are reprinted below. These match the 2010 NEMA premium efficiency ratings. All ratings listed are nominal full load efficiencies, verified in accordance with IEEE Standard 112, Test Method B. Average expected (not guaranteed minimum) power factors shall also be at least the following:

	Full-Load Efficiencies %					
	Open Drip-Proof			Totally Enclosed Fan Cooled		
HP	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
1.0	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2.0	87.5	86.5	85.5	88.5	86.5	85.5
3.0	88.5	89.5	85.5	89.5	89.5	86.5
5.0	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10.0	91.7	91.7	89.5	91.0	91.7	90.2
15.0	91.7	93.0	90.2	91.7	92.4	91.0
20.0	92.4	93.0	91.0	91.7	93.0	91.0
25.0	93.0	93.6	91.7	93.0	93.6	91.7
30.0	93.6	94.1	91.7	93.0	93.6	91.7
40.0	94.1	94.1	92.4	94.1	94.1	92.4
50.0	94.1	94.5	93.0	94.1	94.5	93.0
60.0	94.5	95.0	93.6	94.5	95.0	93.6
75.0	94.5	95.0	93.6	94.5	95.4	93.6
100.0	95.0	95.4	93.6	95.0	95.4	94.1
125.0	95.0	95.4	94.1	95.0	95.4	95.0
150.0	95.4	95.8	94.1	95.8	95.8	95.0
200.0	95.4	95.8	95.0	95.8	96.2	95.4
250.0	95.4	95.8	95.0	95.8	96.2	95.8
300.0	95.4	95.8	95.4	95.8	96.2	95.8
350.0	95.4	95.8	95.4	95.8	96.2	95.8
400.0	95.8	95.8	95.8	95.8	96.2	95.8
450.0	96.2	96.2	95.8	95.8	96.2	95.8
500.0	96.2	96.2	95.8	95.8	96.2	95.8

B. Motor nameplate shall be noted with the above ratings.

2.3 MOTORS ON VARIABLE FREQUENCY DRIVES

A. All motors driven by VFDs shall be premium efficiency type.

B. Motors shall be designed for use with VFDs in variable torque applications with 1.15 service factor. Motors shall not be equipped with auxiliary blowers.

C. Motors driven by VFDs shall have Class F or H insulation and be designated by the motor manufacturer to be suitable for inverter duty service in accordance with NEMA MG 1 Section IV, “Performance Standards Applying to All Machines,” Part 31 “Definite-Purpose Inverter-Fed Polyphase Motors.

D. All 460-volt motors controlled by VFDs shall be equipped with an alternate discharge path, such as a shaft grounding ring or grounding brush, to divert adverse shaft currents from the motor bearings on the drive end of the motor shaft. Motor shafts 2” and larger require shaft grounding on the drive end and the non-drive end. This Contractor shall ensure (via field observation and measurement) that the shaft is effectively grounded upon startup.

1. Providing grounding rings internal to the motor housing is an acceptable solution, provided the motor is affixed with a label clearly indicating the presence of a grounding assembly. The grounding ring shall be listed for 40,000 hours of motor service and shall be accessible via the drive endplate.

2.4 MOTORS FOR WET OR CORROSIVE DUTY

A. Where noted for wet and/or corrosive duty, motors shall be designed for severe duty with cast-iron frame, epoxy finish, stainless steel nameplate, polymer shaft seal, corrosion resistant fasteners and fan, moisture resistant windings, and non-wicking leads.

2.5 MOTORS FOR HAZARDOUS DUTY

A. Where noted for hazardous duty, motors shall be designed for the class, group, and T code listed for the application. Frame sizes 143T and larger shall have normally closed winding thermostats to keep surface temperatures below the nameplate T code under all conditions.

2.6 MOTOR DRIVEN EQUIPMENT

A. No equipment shall be selected or operate above 90% of its motor nameplate rating. Motor size may not be increased to compensate for equipment with efficiency lower than that specified.

B. If a larger motor than specified is required on equipment, the contractor supplying the equipment is responsible for all additional costs due to larger starters, wiring, etc.

2.7 SHEAVES

A. All sheaves shall conform to NEMA Standard MG1-14.42, which lists minimum diameters and maximum overhangs. Locate motors to minimize overhang.

B. When replacing sheaves, use sheaves of at least the originally supplied sizes.

C. Contractor responsible for motor shall also be responsible for replacement sheaves. Coordinate with testing and balancing of the equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

B. For flexible coupled drive motors, mount coupling to the shafts in accordance with the coupling manufacturer's recommendations. Align shafts to manufacturer's requirements or within 0.002 inch per inch diameter of coupling hub.

C. For belt drive motors, mount sheaves on the appropriate shafts per manufacturer's instructions. Use a straight edge to check alignment of the sheaves. Reposition sheaves as necessary so the straight edge contacts both sheave faces squarely. After sheaves are aligned, loosen the adjustable motor base so the belt(s) can be added, and tighten the base so the belt tension is in accordance with the drive manufacturer's recommendations. Frequently check belt tension and adjust if necessary during the first day of operation and again after 80 hours of operation.

END OF SECTION

SECTION 23 05 15

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Variable frequency drives

1.2 RELATED SECTIONS AND WORK

A. Refer to the Variable Frequency Drive Schedule for rating and configuration.

1.3 REFERENCES

A. ANSI/UL Standard 508
B. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems
C. IEEE Standard 519-1992 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters
D. FCC Rules and Regulations, Part 15, Subpart J - Radio Frequency Interference

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Shop Drawings: Include front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

C. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.5 EXTRA MATERIAL

A. Furnish under provisions of Section 26 05 00.

B. Provide two of each air filter.

C. Provide three of each fuse size and type.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Section 26 05 00.

B. Accept controllers on site in original packing. Inspect for damage.

C. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

D. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Maintenance Data: Include spare parts data listing, source and current prices of replacement parts and supplies, and recommended maintenance procedures and intervals.

C. Operation Data: Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

D. Shop Drawings: For each VFD.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

   a. Each installed unit's type and details.

   b. Nameplate legends.

   c. Short-circuit current rating of integrated unit.

   d. UL listing for series rating of overcurrent protective devices in combination controllers.

   e. Features, characteristics, ratings, and factory settings of each motor-control center unit.

2. Wiring Diagrams: Power, signal, and control wiring for VFDs. Provide schematic

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS: Refer to Variable Frequency Drive Schedule.

2.2 DESCRIPTION

A. Converts 60 Hertz input power at voltage specified to a variable AC frequency and voltage for controlling the speed of AC squirrel cage motors. The controller shall be suitable for use with standard NEMA B squirrel cage 1.15 service factor induction motors without requiring any modifications to the motor or the drive.

B. Controller shall have sufficient capacity to provide speed control of the motors shown or noted throughout the specified environmental operating conditions.

C. Controller shall have the functional components listed below:

1. Door interlocked input circuit breaker/fused switch.
2. Input rectifier section to supply fixed DC bus voltage.
3. Smoothing reactor for DC bus.
4. DC bus capacitors.
5. Control transformer.
6. Separate terminal blocks for power and control wiring.
7. Terminal block for operator controls.
8. Sine weighted PWM generating inverter section.

2.3 RATINGS

A. Rated Input Voltage: Refer to Variable Frequency Drive Schedule 480V.

B. Motor Nameplate (Drive Output) Voltage: Refer to Mechanical Schedules.

C. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.

D. Operating Ambient: 0°C to 40°C.

E. Minimum Relative Humidity Range: 5% to 90% (non-condensing).

F. Minimum Elevation without Derating: 3300 feet.

G. Minimum Efficiency at Full Load: 96 percent.

H. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds or 180% for 0.5 seconds.

I. Starting Torque: 100 percent of rated torque or as indicated.

J. Speed Regulation: Plus or minus 1 percent with no motor derating.

2.4 DESIGN

A. Pulse Width Modulated (PWM) Variable Frequency Drives:

1. Converter shall be of a diode bridge design with a sine-weighted PWM inverter section.

2. Main semi-conductors in the inverter section of controller shall be IGBT transistors capable of a carrier switching frequency of up to 8 kHz. If derating of the inverter is necessary to run at 8kHz, then the unit's derated currents must equal or exceed the motor full load currents listed in NEC Table 430-150.

3. All controllers supplied with semi-conductors capable of switching at less than 8,000 Hertz shall be supplied with a motor acoustic noise reduction filter.

4. Pulse width modulated (PWM) drives shall be supplied with drive input line reactors with a minimum impedance of 3%. Reactors shall be installed to filter entire drive input circuit.

5. Pulse width modulated (PWM) drives shall be supplied with drive input harmonic filter to reduce the total harmonic distortion to less than the IEEE519-1992 limits at the utility service entrance.

6. Drives that are located beyond the manufacturer's recommended maximum distance from the motor shall be provided with dV/dt (long lead) filters.

B. All drives shall have built-in diagnostic capability with status and fault indicators mounted on enclosure door. Complete operating instructions for diagnostics shall be mounted inside of the enclosure door.

C. Drive shall restart after power loss and under-voltage fault. The minimum number of restart attempts required shall be three, field adjustable.

D. The drive shall allow unlimited switching of the output without damage to the drive or motor.

2.5 PRODUCT FEATURES

A. Display: Provide integral digital display to indicate all protection faults and drive status (including overcurrent, overvoltage, undervoltage, ground fault, overtemperature, phase loss, input power ON, output voltage, output frequency, and output current.

B. Protection:

1. Input transient protection by means of surge suppressors.

2. Snubber networks to protect against malfunctions due to system transients,

3. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.

4. Motor thermal overload relay(s) adjustable and capable of NEMA Class 10 motor protection and sized per motor nameplate data. When multiple motors are connected to the VFD output, each motor shall have a manual starter with properly sized overload protection.

5. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.

6. Instantaneous line-to-line and line-to-ground overcurrent trips on input and output.

7. Loss-of-phase protection.

8. Reverse-phase protection.

9. Short-circuit protection (fuses or circuit breaker).

10. Motor overtemperature fault.

C. Acceleration Rate Adjustment: 0.5 - 30 seconds.

D. Deceleration Rate Adjustment: 1 - 30 seconds.

E. Minimum Adjustment Range for the Lower Output Frequency shall be: 0 to 40 Hertz.

F. Minimum Adjustment Range for the Upper Output Frequency Range shall be: 40 to 90 Hertz.

G. Minimum Volts/Hertz Range: 3.7 to 8.6 volts/Hertz.

H. Provide MANUAL-OFF-AUTOMATIC selector switch and manual analog speed control mounted on the front of the enclosure.

I. Safety Interlocks: Provide terminals for remote contact to inhibit starting under both manual and automatic mode.

J. Control Interlocks: Provide terminals for remote contact to allow starting in automatic mode.

K. Provide adjustable skip frequencies on the drive output (minimum of three ranges).

L. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption, and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

M. Power-Interruption Protection: After a power interruption, it prevents the motor from re-energizing until the motor has stopped.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fallback based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

Q. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

R. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).

6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

S. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:

   a. 0 to 10-V dc.
   b. 0-20 or 4-20 mA.
   c. Potentiometer using up/down digital inputs.
   d. Fixed frequencies using digital inputs.
   e. RS485.
   f. Keypad display for local hand operation.

3. Output Signal Interface:

   a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:

      1) Output frequency (Hz).
      2) Output current (load).
      3) DC-link voltage (VDC).
      4) Motor torque (percent).
      5) Motor speed (rpm).
      6) Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1A) for remote indication of the following:

   a. Motor running.
   b. Set-point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

T. Communications: Provide a communications card to interface VFD with Facility Management Control System (FMCS). Coordinate interface requirements with the FMCS provided under Section 23 09 00. Interface shall allow all parameter settings of VFD to be programmed via FMCS control and displayed on FMCS operator workstation. Provide capability for VFD to retain these settings within the nonvolatile memory.

U. Two- Contactor Manual Bypass:

1. Provide contactors, motor running overload protection, under-voltage and loss of phase protection, and short circuit protection for full voltage, non-reversing operation of the motor. Include to allow maintenance of inverter during bypass operation.

2. All bypass circuitry shall be located within the same enclosure as the variable frequency drive.

3. All fire alarm and/or smoke control interconnections (e.g., air handling unit shutdown) shall apply regardless of whether control is through VFD or bypass.

4. Provide a Drive-Bypass Selector Switch.

5. Provide nameplate with instructions for switching from drive to bypass and from bypass to drive. Provide instructions for isolating VFD for maintenance.

V. Control:

1. With the "Manual-Off-Auto" switch in the "Manual" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the manual speed potentiometer on the drive door.

2. With the "Manual-Off-Auto" switch in the "Auto" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the input signal from an external source.

3. If applicable, with the "Drive-Bypass" in the "Bypass" position, regardless the position of the "Manual-Off-Auto" switch, the motor shall be connected across the lines and shall be run at full speed.

4. With the "Manual-Off-Auto" switch in the "Off" position, if applicable, the drive run circuit shall be open and the VFD shall not operate.

5. If applicable, signal from the fire alarm control panel shall shut down VFD and bypass.

6. All disconnect switches between VFD and motor(s) shall include an auxiliary contact interlock wired to the VFD fault trip input to shut down the drive upon opening of the disconnect main contacts.

2.6 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. All VFD supplied for fans shall have dynamic or DC injection braking capability to provide a means of rapid deceleration of the AC motor in not more than one (1) minute. Adjust controls to stop the motor within 30 seconds.

C. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

D. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

E. Control Relays: Auxiliary and adjustable time-delay relays.

F. Standard Displays:

1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).

G. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

H. Fabrication:

1. Enclosure: NEMA 250, Type 4X.
2. Finish: Manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. The VFD manufacturer shall provide certification that heat test has been completed.

B. The Electrical Contractor shall have a factory service engineer present for the start-up, field calibration, and check-out of each VFD installed. Factory service engineer shall be required to return to the site for recalibration or set-up should unit not function as specified during system commissioning. All costs shall be a part of This Contract. Provide tag with date and signature of factory service Engineer on inside cover of each drive.

3.2 INSTALLATION

A. Install variable frequency drive equipment in accordance with the manufacturer's instructions.

B. Floor mount VFD on prefabricated or field fabricated supports with controls no higher than 6'-6" and no lower than 3'-0" AFF. Mount supports on 1/2" thick vibration isolation pads set on concrete housekeeping pads.

C. Provide engraved phenolic nameplates under the provisions of Section 26 05 53.

D. Connections: All conduit connections to the VFD shall be by flexible conduit.

E. Input, output, and control wiring shall each be run in separate conduits.

F. All interlocking required by the drive manufacturer shall be the responsibility of the Electrical Contractor.

3.3 STARTUP AND COMMISSIONING

A. Verify all settings, parameters, and adjustments with other contractors prior to startup. Make all adjustments and setting to coordinate with controls and equipment.

B. Accelerate the motor to full speed and verify operation. Decelerate the motor to a stop and verify operation. Slowly operate the motor over the speed range and check for resonance.

C. Make all adjustments and settings to coordinate with controls and equipment prior to Substantial Completion. Verify that drive is set for auto restart after power loss and undervoltage fault.

D. Document settings in the Operations and Maintenance manual.

END OF SECTION

SECTION 23 05 53

HVAC IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Identification of products installed under Division 23.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. 3M, Bunting, Calpico, Craftmark, Emedco, Kolbi Industries, Seton, W.H. Brady, Marking Services.

2.2 MATERIALS

A. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Marker lengths and letter sizes shall be at least the following:

OD of Pipe or insulation	Marker Length	Size of Letters
Up to and including 1-1/4”	8”	1/2”
1-1/2” to 2”	8”	3/4”
2-1/2” to 6”	12”	1-1/4”
8” to 10”	24”	2-1/2”
Over 10”	32”	3-1/2”

Plastic tags may be used for outside diameters under 3/4".

B. Plastic Nameplates: Laminated three-layer phenolic with engraved black, 1/4" minimum letters on light contrasting background.

C. Plastic Tags: Minimum 1-1/2" square or round laminated three-layer phenolic with engraved, 1/4" minimum black letters on light contrasting background.

D. Stencil Painted Pipe Markers: Use industrial enamel spray paint per ANSI Standard A13.1. Indicate fluid conveyed and flow direction.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturer’s recommendations.

B. Degrease and clean surfaces to receive adhesive for identification materials.

C. Valves:

1. All valves (except shutoff valves at equipment) shall have numbered tags.

2. Provide or replace numbered tags on all existing valves that are connected to new systems or that have been revised.

3. Provide all existing valves used to extend utilities to this project with numbered tags. Review tag numbering sequence with the Owner prior to ordering tags.

4. Secure tags with heavy duty key chain and brass "S" link or with mechanically fastened plastic straps.

5. Attach to handwheel or around valve stem. On lever operated valves, drill the lever to attach tags.

6. Number all tags and show the service of the pipe.

7. Provide one Plexiglas framed valve directory listing all valves, with respective tag numbers, uses and locations. Mount directory in location chosen by the Architect/Engineer.

D. Pipe Markers:

1. Stencil Painted Pipe Markers:

a. Remove rust, grease, dirt, and all foreign substances from the pipe surface.
b. Apply primer on non-insulated pipes before painting.
c. Use background and letter colors as scheduled later in this section.

2. Apply markers and arrows in the following locations where clearly visible:

a. At each valve.
b. On both sides of walls that pipes penetrate.
c. At least every 20 feet along all pipes.
d. On each riser and each leg of each "T" joint.
e. At least once in every room and each story traversed.

E. Equipment:

1. All equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function such as air handling units, exhaust fans, filters, reheat coils, dampers, etc.; shall have nameplates or plastic tags listing name, function, and drawing symbol. Do not label exposed equipment in public areas.

2. Fasten nameplates or plastic tags with stainless steel self-tapping screws or permanently bonding cement.

F. Miscellaneous:

1. Attach self-adhesive vinyl labels at all duct access doors used to reset fusible links or actuators on fire, fire/smoke, or smoke dampers. Lettering shall be a minimum of 1/2" high. Labels shall indicate damper type.

2. Provide engraved plastic tags at all hydronic or steam system make-up water meters.

3.2 SCHEDULE

A. Pipes to be marked shall be labeled with the text as shown in the following table regardless of which method or material is used:

Pipe Service	Lettering Color	Background Color
HEATING WATER SUPPLY	Black	Yellow
HEATING WATER RETURN	Black	Yellow
LOW PRESSURE CONDENSATE	Black	Yellow
PUMPED CONDENSATE	Black	Yellow
CONDENSATE DRAIN	Black	Yellow
NATURAL GAS	Black	Yellow
REFRIGERANT LIQUID	Black	Yellow
REFRIGERANT SUCTION	Black	Yellow

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Testing, adjusting, and balancing of air systems.
B. Measurement of final operating condition of HVAC systems.

1.2 QUALITY ASSURANCE

A. Agency shall be a company specializing in the adjusting and balancing of systems specified in this section with minimum three years' experience. Perform work under supervision of AABC Certified Test and Balance Engineer, NEBB Certified Testing, Balancing and Adjusting Supervisor, SMARTA Certified Air and Hydronic Balancer, or TABB Certified Supervisor.

B. Work shall be performed in accordance with the requirements of the references listed at the start of this section.

1.3 REFERENCES

A. AABC - National Standards for Total System Balance, 2002.
B. ADC – Test Code for Grilles, Registers, and Diffusers.
C. AMCA – Publication 203-90; Field Performance Measurement of Fan Systems.
D. ASHRAE - 2003 HVAC Applications Handbook; Chapter 37, Testing, Adjusting and Balancing.
E. ASHRAE/ANSI - Standard 111-1988; Practices for Measurement, Testing, Adjusting and Balancing of Building HVAC&R Systems.
F. NEBB - Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems, Sixth Edition, 1998.
G. SMACNA - HVAC Systems; Testing, Adjusting and Balancing, Third Edition, 2002.
H. TABB – International Standards for Environmental Systems Balance.

1.4 SUBMITTALS

A. Submit copies of report forms, balancing procedures, and the name and qualifications of testing and balancing agency for approval within 30 days after award of Contract.

B. Electronic Copies:

1. Submit a certified copy of test reports to the Architect/Engineer for approval. Electronic copies shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Copies that are not legible will be returned to the Contractor for resubmittal. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

2. Electronic file size shall be limited to a maximum of 10MB. Larger files shall be divided into files that are clearly labeled as "1 of 2", "2 of 2", etc.

3. All text shall be searchable.

4. Bookmarks shall be used. All bookmark titles shall be an active link to the index page and index tabs.

C. Paper Copies:

1. Submit four (4) certified copies of test reports to the Architect/Engineer for approval in soft cover, 3-hole binder manuals, with cover identification. Include index page and indexing tabs.

1.5 REPORT FORMS

A. Submit reports on AABC, SMACNA or NEBB forms. Use custom forms approved by the Architect/Engineer when needed to supply specified information.

B. Include in the final report a schematic drawing showing each system component, including balancing devices, for each system. Each drawing shall be included with the test reports required for that system. The schematic drawings shall identify all testing points and cross-reference these points to the report forms and procedures.

C. Refer to PART 4 for required reports.

1.6 WARRANTY/GUARANTEE

A. The TAB Contractor shall include an extended warranty of 90 days after owner receipt of a completed balancing report, during which time the Owner may request a recheck of terminals, or resetting of any outlet, coil, or device listed in the test report. This warranty shall provide a minimum of 24 manhours of onsite service time. If it is determined that the new test results are not within the design criteria, the balancer shall rebalance the system according to design criteria.

B. Warranty/Guarantee must meet one of the following programs: TABB International Quality Assurance Program, AABC National Project Performance Guarantee, NEBB's Conformance Certification.

1.7 SCHEDULING

A. Coordinate schedule with other trades. Provide a minimum of seven days' notice to all trades and the Architect/Engineer prior to performing each test.

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. All procedures must conform to a published standard listed in the References article of this section. All equipment shall be adjusted in accordance with the manufacturer's recommendations. Any system not listed in this specification but installed under the contract documents shall be balanced using a procedure from a published standard listed in the References article.

B. The Balancing Contractor shall incorporate all pertinent documented construction changes (e.g. submittals/shop drawings, change orders, RFIs, ASIs, etc.) and include in the balancing report.

C. Recorded data shall represent actual measured or observed conditions.

D. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing is complete, close probe holes and patch insulation with new materials as specified. Restore vapor barrier and finish as specified.

E. Permanently mark setting of valves, dampers, and other adjustment devices allowing for settings to be restored. Set and lock memory stops.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, plugging test holes, and restoring thermostats to specified settings.

G. The Balancing Contractor shall measure terminal air box air flow, and the TCC shall adjust DDC readout to match. Refer to Section 23 09 00 for additional information.

H. Installations with systems consisting of multiple components shall be balanced with all system components operating.

3.2 EXAMINATION

A. Before beginning work, verify that systems are complete and operable. Ensure the following:

1. General Equipment Requirements:

   a. Equipment is safe to operate and in normal condition.
   b. Equipment with moving parts is properly lubricated.
   c. Temperature control systems are complete and operable.
   d. Proper thermal overload protection is in place for electrical equipment.
   e. Direction of rotation of all fans and pumps is correct.
   f. Access doors are closed and end caps are in place.

2. Duct System Requirements:

   a. All filters are clean and in place. If required, install temporary media.
   b. Duct systems are clean and free of debris.
   c. Fire/smoke and manual volume dampers are in place, functional and open.
   d. Air outlets are installed and connected.
   e. Duct system leakage has been minimized.

3. Pipe System Requirements:

   a. Coil fins have been cleaned and combed.
   b. Hydronic systems have been cleaned, filled, and vented.
   c. Strainer screens are clean and in place.
   d. Shutoff, throttling and balancing valves are open.

B. Report any defects or deficiencies to Engineer.

C. Promptly report items that are abnormal or prevent proper balancing.

D. If, for design reasons, system cannot be properly balanced, report as soon as observed.

E. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to the Engineer for spot checks during testing.

B. Instruments shall be calibrated within six months of testing performed for project, or more recently if recommended by the instrument manufacturer.

3.4 INSTALLATION TOLERANCES

A. ± 10% of scheduled values:

1. Adjust air inlets and outlets to ± 10% of scheduled values.

2. Adjust piping systems to ± 10% of design values.

3.5 ADJUSTING

A. After adjustment, take measurements to verify balance has not been disrupted or that disruption has been rectified.

B. Once balancing of systems is complete, at least one damper or valve must be 100% open.

C. After testing, adjusting and balancing are complete, operate each system and randomly check measurements to verify system is operating as reported in the report. Document any discrepancies.

D. Contractor responsible for each motor shall also be responsible for replacement sheaves. Coordinate with contractor.

E. Contractor responsible for pump shall trim impeller to final duty point as instructed by this contractor on all pumps not driven by a VFD. Coordinate with contractor.

3.6 SUBMISSION OF REPORTS

A. Fill in test results on appropriate forms.

PART 4 - SYSTEMS TO BE TESTED, ADJUSTED AND BALANCED

4.1 GENERAL REQUIREMENTS

A. Title Page:

1. Project name.
2. Project location.
3. Project Architect.
4. Project Engineer (IMEG Corp.).
5. Project General Contractor.

6. TAB Company name, address, phone number.
7. TAB Supervisor's name and certification number.
8. TAB Supervisor's signature and date.
9. Report date.

B. Report Index

C. General Information:

1. Test conditions.
2. Nomenclature used throughout report.
3. Notable system characteristics/discrepancies from design.
4. Test standards followed.
5. Any deficiencies noted.
6. Quality assurance statement.

D. Instrument List:

1. Instrument.
2. Manufacturer, model, and serial number.
3. Range.
4. Calibration date.

4.2 AIR SYSTEMS

A. Air Moving Equipment:

1. General Requirements:
   a. Drawing symbol.
   b. Location.
   c. Manufacturer, model, arrangement, class, discharge.
   d. Fan RPM.
   e. Multiple RPM fan curve with operating point marked. (Obtain from equipment supplier).
   f. Final frequency of motor at maximum flow rate (on fans driven by VFD).
2. Flow Rate:
   a. Supply flow rate (cfm): specified and actual.
   b. Return flow rate (cfm): specified and actual.
   c. Outside flow rate (cfm): specified and actual.
   d. Exhaust flow rate (cfm): specified and actual.
3. Pressure Drop and Pressure:
   a. Filter pressure drop: specified and actual.
   b. Total static pressure: specified and actual. (Indicate if across fan or external to unit).
   c. Inlet pressure.
   d. Discharge pressure.

B. Fan Data:

1. Drawing symbol.
2. Location.
3. Manufacturer and model.
4. Flow rate (cfm): specified and actual.

5. Total static pressure: specified and actual. (Indicate measurement locations).
6. Inlet pressure.
7. Discharge pressure.
8. Fan RPM.

C. Electric Motors:

1. Drawing symbol of equipment served.
2. Manufacturer, Model, Frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps in each phase.

D. Air Terminal (Inlet or Outlet):

1. Drawing symbol.
2. Room number/location.
3. Terminal type and size.
4. Velocity: specified and actual.
5. Flow rate (cfm): specified and actual.
6. Percent of design flow rate.

END OF SECTION

SECTION 23 21 00

HYDRONIC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings.
B. Valves.
C. Heating Water Piping System.
D. Glycol Water Piping System.
E. Chilled Water Piping System.
F. Condenser Water Piping System.
G. Heating/Cooling Water Piping System.
H. Acoustical Lagging.

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials, Procedures, and Operators: Conform to ASME Section 9, ANSI/AWS D1.1, and applicable state labor regulations.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00. Include data on pipe materials, fittings, valves, and accessories. Include manufacturers' support spacing requirements for plastic piping.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent entrance of foreign matter into pipe and to prevent exterior corrosion.

B. Deliver and store valves in shipping containers with labeling in place.

PART 2 - PRODUCTS

2.1 GLYCOL HEATING WATER

A. Design Pressure: 125 psig.
Maximum Design Temperature: 225ºF.

B. Piping - 2" and Under:

1. Pipe: Standard weight black steel, threaded and coupled, ASTM A53; Type E, F, or S; Grade B.

2. Joints: Screwed.

3. Fittings: Class 125 cast iron, ASTM A126, ASME B16.4; or Class 150 malleable iron, ASTM A197, ASME B16.3.

4. Unions: Class 150 malleable iron, ANSI B16.39, ground joint with copper or copper alloy-to-iron seat.

C. Piping - 2-1/2" and Over:

1. Pipe: Standard weight black steel, beveled ends, ASTM A53, Type E or S, Grade B.

2. Joints: Butt-welded or flanged.

3. Fittings: Standard weight wrought steel, butt-welding type, ASTM A234, ASME B16.9.

4. Flanges: Class 150 forged steel, welding neck or slip-on, ASTM A181 or A105, Class 60, ASME B16.5 up to 24" and B16.47 above 24". ASME B16.1 for flanges mating with flat face equipment flanges.

D. Shutoff Valves:

1. Gate Valves:

a. GA-1: 2" and under, 125 psi S @ 353ºF, 300 psi WOG @ 150ºF, screwed, bronze, rising stem, screwed bonnet. Crane #431, Hammond #IB641, Stockham #B122, Walworth #56, Milwaukee #1150, Watts #B-3210, NIBCO #T-131.

b. GA-2: 2-1/2" thru 12", 125 psi S @ 353°F, 200 psi WOG @ 150°F, flanged, iron body, bronze mounted, OS&Y. Crane #465-1/2, Hammond, Stockham #G623, Walworth, Milwaukee #F2885, Watts #F-503, NIBCO F-617-O.

2. Ball Valves:

a. BA-1: 3" and under, 125 psi saturated steam, 600 psi WOG, full port, screwed or solder ends (acceptable only if rated for soldering in line with 470°F melting point of lead-free solder), bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and stem, Teflon seats and seals. Apollo #77C-140, Stockham #S-206 BR1-R, Milwaukee #BA-400, Watts, Nibco #585-70-66, National Utilities Co., RUB.

NOTES:

1) Provide extended shaft for all valves in insulated piping.

2) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°F, heating water piping over 120°F, steam, condensate, boiler feed water piping, compressed air piping and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

b. BA-1A: 2-1/2" and 3", 125 psi saturated steam, 275 psi WOG ANSI Class, 150 psi standard port, carbon steel body stainless steel ball and trim, Teflon seats and seals. Apollo #88A-100, Nibco #F510-CS/66, Milwaukee #F90.

NOTES:

1) Provide extended shaft with operating handle of non-thermal conductive material and protective sleeve that allows operation of valve, adjustment of the packing, and adjustment of the memory stop without breaking the vapor seal or disturbing the insulation for all valves in insulated piping.

2) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°F, heating water piping over 120°F, steam, condensate, boiler feed water piping, compressed air piping and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

3. Butterfly Valves:

a. BF-1:

1) 2-1/2" thru 6", 175 psi CWP, elastomers rated for 20°F to 225°F continuous and 250°F intermittent at 125 psig, fully lugged end, ductile or cast iron body (not in contact with fluid); bronze, aluminum-bronze or EPDM coated ductile iron disc; EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to centerline of valve body (for pipe extension without draining system), 10 position locking operator up to 6" size. Cv of at least 1580in 6" size. Center Line Series 200, Keystone #222, Watts #DBF-03-121-1P, Nibco N200 Series or LD2000 Series, Milwaukee CL series, Hammond 5200 series.

E. Throttling Valves:

1. Globe Valves:

a. GL-1: 3" and under, 125 psi saturated steam, 300 psi WOG, screwed, bronze. Crane #7TF, Stockham #B22T, Walworth #95, Milwaukee #590, Hammond #IB413T, Watts #B-4010-T, or NIBCO #T-235.

b. GL-2: 4" thru 10", 125 psi @ 353ºF, 200 psi WOG @ 150ºF, flanged, iron body, bronze mounted. Crane #351, Hammond #IR116, Stockham #G-512, Walworth #906F, Milwaukee #F2981, Watts #F-501, or NIBCO #F-718.

2. Ball Valves:

a. BA-9: 2" and under, 125 psi saturated steam, 600 psi WOG, standard port, screwed (solder ends are acceptable only if rated for soldering in line with 470°F melting point of lead-free solder), bronze body and ball of copper alloy containing less than 15% zinc, chrome plated or stainless steel ball, Teflon seats and seals with memory stop. Apollo #70-120, Stockham #S-216BR-R, Milwaukee #BA-100, Watts #B-6000, Hammond #8501, Nibco #580-70.

NOTE: Provide extended shaft with operating handle of non-thermal conductive material and protective sleeve that allows operation of valve, adjustment of the packing, and adjustment of the memory stop without breaking the vapor seal or disturbing the insulation for all valves in insulated piping.

3. Butterfly Valves:

a. BF-4:

1) 2-1/2" thru 6", 175 psi CWP, elastomers rated for 20ºF to 225°F continuous and 250ºF intermittent at 125 psig, fully lugged or grooved end, ductile or cast iron body (not in contact with fluid); bronze, aluminum-bronze or EPDM coated ductile iron disc; EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to centerline of valve body (for pipe extension without draining system), infinite position locking operator with memory stop up to 6" size. Cv of at least 1580 in 6" size. Victaulic #300, Center Line Series 200, Keystone #222, Watts #DBF-03-121-1P, NIBCO LD2000 Series, Milwaukee CL series, Hammond 5200 series.

F. Check Valves:

1. CK-1: 2" and under, 125 psi @ 353ºF, 200 psi WOG @ 150ºF, screwed, bronze, horizontal swing. Crane #37, Hammond #IB904, Stockham #B319, Walworth #406, Milwaukee #509, Watts #B-5000, or NIBCO #T-413.

2. CK-13: 2-1/2" thru 12", 200# WOG, double disc wafer type, iron body, bronze or aluminum-bronze discs, 316SS shaft and spring, Viton, EPDM or BUNA-N, Cv of at least 700 in 6" size. Mueller Steam Specialty Co. #71-AHB-6-H, Stockham #WG-961, NIBCO W-920-W, Crane, Victaulic #716/716H.

2.2 EQUIPMENT DRAINS AND OVERFLOWS

A. Steel Pipe: ASTM A53, Schedule 40 galvanized.

1. Fittings: Galvanized cast iron screwed drainage type, ASME B16.12.

2. Joints: Screwed.

3. Service: Not allowed on boiler drains and overflow.

B. Steel Pipe: ASTM A53. [for boiler drains only]

1. Pipe: Standard weight black steel, threaded and coupled, ASTM A53.

2. Joints: Screwed.

3. Fittings: Class 125 cast iron, ASTM A126, ASME B16.4.

C. Shutoff Valves:

1. Ball Valves:

a. BA-1: 3" and under, 125 psi saturated steam, 600 psi WOG, full port, screwed or solder ends (acceptable only if rated for soldering in line with 470°F melting point of lead-free solder), bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and trim, Teflon seats and seals. Apollo #77C-140, Stockham #S-206 BR1-R, Milwaukee #BA-400, Watts, Nibco #585-70-66, National Utilities Co., RUB.

NOTES:

1) Provide extended shaft for all valves in insulated piping.

2) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°F, heating water piping over 120°F, steam, condensate, boiler feed water piping, compressed air piping and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

2.3 AIR VENTS

A. At end of main and other points where large volume of air may be trapped - Use 1/4" globe valve, angle type, 125 psi, Crane #89, attached to coupling in top of main, 1/4" discharge pipe turned down with cap.

B. On branch lines and small heating units - Use coin-operated air vent equal to B&G #4V, attached to 1/8" coupling in top of pipe. Install air vents on all coils and terminal heating units.

2.4 AUTOMATIC AIR VENTS

A. Low capacity automatic air vent (for bladder tank anti-thermosyphon loops). Maximum operating pressure and temperature of at least 240°F and 125 psi, 1/2" or 3/4" inlet. B&G #87, Armstrong, Spirotherm, Taco, or Watts.

B. High/low capacity automatic air vent (for air separator connection). Maximum operating pressure and temperature of at least 240°F and 125 psi, 3/4" inlet, 3/8” minimum outlet. B&G #107, Armstrong, Spirotherm, Taco, or Watts.

2.5 MAKE-UP WATER ACCESSORIES

A. Relief Valve:

1. For water fill lines to hydronic systems.

2. Cast iron or bronze body, 1/2" or 3/4" screwed connections, 125 psig working pressure, 225°F maximum temperature. Minimum 500,000 Btuh capacity at 30 psig. Manual test lever.

3. Acceptable Manufacturers: Armstrong, Bell & Gossett, Conbraco, Taco, Watts.

2.6 SAFETY RELIEF VALVES

A. SRV-1 (Hydronic Heating Systems): Spring-loaded disc type with cast iron or bronze body, bronze or stainless steel disc, side outlet and lifting lever for maximum service of 125 psig at 250ºF. For relieving water during pressure fluctuations and in case of control failure. Capacities shall be ASME Section IV certified and labeled. Acceptable Manufacturers: Kunkle # 537, B&G, Conbraco, McDonnell & Miller, or Watts.

2.7 CONNECTIONS BETWEEN DISSIMILAR METALS

A. Connections between dissimilar metals shall be insulating dielectric types that provide a water gap between the connected metals, and that either allow no metal path for electron transfer or that provide a wide water gap lined with a non-conductive material to impede electron transfer through the water path.

B. Joints shall be rated for the temperature, pressure, and other characteristics of the service in which they are used, including testing procedure.

C. Aluminum, iron, steel, brass, copper, bronze, and stainless steel are commonly used and require isolation from each other with the following exceptions:

1. Iron, steel, and stainless steel connected to each other.

2. Brass, copper, and bronze connected to each other.

3. Brass or bronze valves and specialties connected in closed systems with steel, iron, or stainless steel on both sides of the brass or bronze valves and specialties. Where two or more brass or bronze items occur together, they shall be connected with brass nipples. Brass or bronze valves and specialties cannot be used as a dielectric separation between pipe materials.

D. Dielectric protection is required at connections to equipment of a material different than the piping.

E. Screwed Joints (acceptable up to 2" size):

1. Dielectric waterway rated for 300 psi CWP and 225°F.

2. Acceptable Manufacturers: Elster Group ClearFlow fittings, Victaulic Series 647, Grinnell Series 407, Matco-Norca.

F. Flanged Joints (any size):

1. Use 1/8" minimum thickness, non-conductive, full-face gaskets.

2. Employ one-piece molded sleeve-washer combinations to break the electrical path through the bolts.

3. Sleeve-washers are required on one side only, with sleeves minimum 1/32" thick and washers minimum 1/8" thick.

4. Install steel washers on both sides of flanges to prevent damage to the sleeve-washer.

5. Separate sleeves and washers may be used only if the sleeves are manufactured to exact lengths and installed carefully so the sleeves must extend partially past each steel washer when tightened.

6. Acceptable Manufacturers: EPCO, Central Plastics, Pipeline Seal and Insulator, F. H. Maloney, or Calpico.

2.8 LOCK OUT TRIM

A. Provide lock out trim for all quarter turn valves opening to atmosphere installed in heating water piping over 120°F and as indicated on the drawings.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends, remove burrs, bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Connect to all equipment with flanges or unions.

D. After completion, fill, clean, and treat systems. Refer to Section 23 25 00 for treatment.

3.2 TESTING PIPING

Glycol Heating Water:

1. Complete testing before insulation is applied. If insulation is applied before pipe is tested and a leak ruins the insulation, replace all damaged insulation.

2. Test the pipe with 100 psig water pressure. Hold pressure for at least two hours.

3. Test to be witnessed by the Engineer or their representative, if requested by the Engineer.

3.3 CLEANING PIPING

A. Assembly:

1. Prior to assembly of pipe and piping components, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of the Architect/Engineer. Blow chips and burrs out of pipe before assembly. Wipe cutting oil from internal and external surfaces.

2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing to the degree consistent with good piping practices.

3. Notify the Architect/Engineer prior to starting any post erection cleaning operation in time to allow witnessing the operation. Properly dispose of cleaning and flushing fluids.

4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, control valves, and balance valves, and verify all strainer screens are in place.

3.4 INSTALLATION

A. General Installation Requirements:

1. Route piping in orderly manner, straight, plumb, with consistent pitch, parallel to building structure, with minimum use of offsets and couplings. Provide only offsets required for needed headroom or clearance and needed flexibility in pipe system.

2. Install piping to conserve building space, and not interfere with other work.

3. Group piping whenever practical at common elevations.

4. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

5. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it. Where pipe sizes are not shown, the larger size in either direction shall continue through the fitting nearest to the indication of a smaller pipe size.

6. Install bell and spigot pipe with bells upstream.

7. Seal pipes passing through exterior walls with a wall seal per Section 23 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe.

8. Branch takeoffs shall be from the top side (if branch is two sizes smaller than main), or any angle from the horizontal plane to the top of piping.

B. Installation Requirements in Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment plus its required clearance space.

C. Valves/Fittings and Accessories:

1. Provide chain operators for all valves over 2" size that are over 10'-0" above finished floor. Extend to 7'-0" above finished floor.

2. Provide valve position indicator on all valves 10’-0” or greater above finish floor and not located above ceiling.

3. Provide clearance for installation of insulation, and access to valves and fittings.

4. Provide access doors where valves are not exposed.

5. Where a manual balance valve is shown to be installed in series with a service (isolation) valve, separate balance and service (isolation) valves shall be installed.

6. Install balancing valves with the manufacturer's recommended straight upstream and downstream diameters of pipe.

7. Prepare pipe, fittings, supports, and accessories for finish painting.

8. Install valves with stems upright or horizontal, not inverted, except install manual quarter turn valves in radiation cabinets and all butterfly valves with stems horizontal.

9. Provide shutoff valves and flanges or unions at all connections to equipment, traps, and items that require servicing.

10. Provide flanges or unions at all final connections to equipment, traps and valves.

11. Arrange piping and piping connections so equipment may be serviced or totally removed without disturbing piping beyond final connections and associated shutoff valves.

3.5 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories prior to installation. Immediately reject and remove from the job any items which are unsuitable, cracked or otherwise defective.

B. All pipe, fittings, valves, equipment and accessories shall have factory-applied markings, stampings, or nameplates sufficient to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any unclean item.

D. During construction, until system is fully operational, keep all openings in piping and equipment closed at all times except when actual work is being performed on that item. Closures shall be plugs, caps, blind flanges or other items designed for this purpose.

E. Change direction of pipes only with fittings or pipe bends. Change size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. **2-1/2" and larger fittings shall be long radius type**, unless otherwise shown on the drawings or specified. Construct welded elbows of angles not available as standard fittings by cutting and welding standard elbows to form smooth, long radius fittings.

F. Use full and double lengths of pipe wherever possible.

G. Unless otherwise indicated, install all inlet and outlet piping, including shutoff valves and strainers, to coils, pumps and other equipment at line size with reduction in size being made only at control valve or pump.

H. Cut all pipe to exact measurement and install without springing or forcing except in the case of expansion loops where cold springing is indicated on the drawings.

I. Do not create, even temporarily, undue loads, forces or strains on valves, equipment or building elements.

3.6 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all horizontal pipes, including branches, shall pitch 1" in 40 feet to low points for complete drainage, removal of condensate, and venting.

B. Provide drain valves at all low points of water piping systems or where indicated on drawings for complete or sectionalized draining. Drain valves are defined above.

C. Use eccentric reducing fittings on horizontal runs when changing size for proper drainage and venting. Install all liquid lines with top of pipe and eccentric reducers in a continuous line.

D. Provide air vents at all high points and wherever else required for elimination of air in all water piping systems. Do not use automatic air vents in glycol systems unless they are piped to the fill tank.

E. Air vents shall be in accessible locations. If needed to trap and vent air in a remote location, a 1/8" pipe shall connect the tapping location to a venting device in an accessible location.

F. All vent and drain piping shall be of same materials and construction as the service involved.

3.7 BRANCH CONNECTIONS

A. Make branch connections with standard tee or cross fittings of the type required for the service unless otherwise specified herein or detailed on the drawings.

B. At the option of the Contractor, branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

C. Use of forged weld-on fittings is also limited as follows:

1. Must have at least same pressure rating as the main.
2. Header or main must be 2-1/2" or over.
3. Branch line is at least two pipe sizes under header or main size.

3.8 JOINING OF PIPE

A. Threaded Joints:

1. Ream pipe ends and remove all burrs and chips.
2. Protect plated pipe and valve bodies from wrench marks when making up joints.
3. Apply Teflon tape to male threads.

B. Flanged Joints:

1. Bronze flanges shall conform to B16.24 and ductile iron flanges to B16.42. Steel flanges shall be raised face except when bolted to flat face cast iron flange.

2. Bolting shall be ASTM A307 Grade B with bolts and heavy hexagonal nuts conforming to ASME B18.2.1 and B18.2.2.

3. Torque bolts in at least three passes, tightening to 1/3, 2/3, and final torque in a cross pattern with an indicating torque wrench for equal tension in all bolts.

4. Gaskets for flat face flanges shall be full-face type. Gaskets for raised faced flanges shall conform to requirements for "Group I gaskets" in ASME B16.5. All gaskets shall conform to ASME B16.21. Unless otherwise specified, gaskets shall meet the following requirements:

   a. Gasket material and thickness approved by manufacturer for intended service, chemical compatibility, pipe system test pressure, and operating temperature range.

   b. Maximum pressure rating of at least 250 psig.

   c. Minimum temperature rating: -10°F.

   d. Maximum temperature rating of at least 170°F for water and glycol solution systems operating 140°F and less.

   e. Maximum temperature rating of at least 250°F for water and glycol solution systems operating above 140°F and up to 180°F.

C. Welded Joints:

1. Welding of all pipe joints, both as to procedures and qualification of welders, shall be in accordance with Section IX, ASME "Boiler & Pressure Vessel Code" unless local codes take precedence.

2. Furnish certificates qualifying each welder to the Owner's Representative prior to start of work.

3. The Owner's Representative reserves the right to require qualifying demonstration, at the Contractor's expense, of any welders assigned to the job.

4. Ends of pipe and fittings to be joined by butt-welding shall be beveled, cleaned to bare metal and internal diameters aligned before tack welding.

5. Single-welded butt joints may be employed with or without the use of backing rings in all sizes. Where backing rings are not used on pumped pressurized systems, the root side of the weld shall either be chipped or ground flush with the piping wall. For services such as vents, overflows, and gravity drains, the backing ring may be eliminated, and the root of the weld need not be chipped or ground. Backing rings shall be of the material being welded.

END OF SECTION

SECTION 23 31 00

DUCTWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Galvanized Ductwork
B. Ductwork Reinforcement
C. Ductwork Sealants
D. Rectangular Ductwork
E. Round and Flat Oval Ductwork
F. Exposed Ductwork (Rectangular, Round, or Oval)
G. Flexible Duct
H. Leakage Testing
I. Ductwork Penetrations
J. Duct Cleaning
K. Painting

1.2 DEFINITIONS

A. Duct Sizes shown on drawings are inside clear dimensions. Maintain clear dimensions inside any lining.

B. Transitions are generally not shown in single-line ductwork. Where sizes change at a divided flow fitting, the larger size shall continue through the fitting.

PART 2 - PRODUCTS

2.1 GALVANIZED DUCTWORK

A. General Requirements:

1. Duct and reinforcement materials shall conform to ASTM A653 and A924.

2. Interior Ductwork and reinforcements: G60 galvanized (0.60 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise.

3. Exterior Ductwork: G90 galvanized (0.90 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise. G60 is not acceptable for exterior use.

4. Ductwork reinforcement shall be of galvanized steel.

5. Ductwork supports shall be of galvanized or painted steel. Slip cable hangers are acceptable. Acceptable manufacturers are Gripple, Ductmate, Duro Dyne, or Architect/Engineer approved.

6. Strap hanger shall be a minimum of 1 inch, 18 gauge galvanized steel attached to the bottom of ducts at 8'-0" OC and as required by CMC/UMC and SMACNA guidelines.

7. All fasteners shall be galvanized or cadmium plated.

2.2 DUCTWORK REINFORCEMENT

A. General Requirements:

1. All reinforcement shall be external to the duct except that tie rods may be used with the following limitations.

a. Ducts must be over 18” wide.

b. Duct dimensions must be increased 2” in one dimension (h or w) for each row of tie rods installed.

c. Tie rods must not exceed 1/2” diameter.

d. Manufacturer of tie rod system must certify pressure classifications of various arrangements, and this must be in the shop drawings.

2.3 DUCTWORK SEALANTS

A. One-part joint sealers shall be water-based mastic systems that meet the following requirements: maximum 48-hour cure time, service temperature of -20°F to +175°F, resistant to mold, mildew and water, flame spread rating below 25 and smoke-developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes. Mastic used to seal flexible ductwork shall be marked UL 181B-M.

B. Two-part joint sealers shall consist of a minimum 3” wide mineral-gypsum compound impregnated fiber tape and a liquid sealant. Sealant system shall meet the following requirements: maximum 48-hour cure time, service temperature of 0°F to 200°F, resistant to mold, mildew, and water, flame spread rating below 25 and smoke developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes.

C. Pressure sensitive tape used for sealing ductwork shall be minimum 2.5-inch wide, listed and marked UL 181A-P, having minimum 60 oz/inch peel adhesion to steel, and service temperature range from -20°F to +250°F.

D. Where pressure sensitive tape is called for on drawings and specifications for sealing flexible ductwork, tape shall be minimum 2.5-inch wide, UL 181 B-FX listed, and marked tape having minimum 60 oz/inch peel adhesion to steel and service temperature range from -20°F to +250°F. Acceptable manufacturers include: Venture Tape 1581A, Compac #340, Scotch Foil Tape 3326, Polyken 339.

2.4 RECTANGULAR DUCT - SINGLE WALL

A. General Requirements:

1. All ductwork gauges and reinforcements shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space consuming reinforcement.

2. Transitions shall not exceed the angles in Figure 4-7.

B. Exceptions and modifications to the 2005 HVAC Duct Construction Standards are:

1. All ducts shall be cross-broken or beaded.

2. Snap lock seams are not permitted.

3. Turning vanes shall be used in all 90° mitered elbows, unless clearly noted otherwise on the drawings. Vanes shall be as follows:

    a. Type 1:

        1) **Description**: Single wall type with 22-gauge (0.029”) or heavier vanes, 3-1/4" blade spacing, and 4” to 4-1/2" radius. Vanes hemmed if recommended by runner manufacturer. Runners shall have extra-long locking tabs. C-value independently tested at below 0.26. EZ Rail II by Sheet Metal Connectors or equal.

        2) **Usage**: Limited to 3,000 fpm and vane lengths 36” and under.

    b. Type 2:

        1) **Description**: Double wall type with 3-1/4" blade spacing, 4-1/2" radius, 24-gauge minimum, and SMACNA Type 1 runners. C-value below 0.27.

        2) **Usage**: No limits other than imposed by the manufacturer. Provide intermediate support for vanes over 48” long.

    c. Type 3 (acoustical - where acoustical lagging is located or as noted on drawings):

        1) **Description**: Same as Type 2, except filled with fiberglass and with slotted or perforated inner curve. Minimum insertion loss of 9 dB at 250 Hz and 6 dB at 1 KHz.

        2) **Usage**: No limits other than imposed by the manufacturer. Provide intermediate support for vanes over 48” long.

    d. Turning vanes shall operate quietly. Repair or replace vanes that rattle or flutter.

    e. Runners must be installed at a 45° angle. Elbows with different size inlet and outlet must be radius type.

    f. Omitting every other vane is prohibited.

4. Where smooth radius rectangular elbows are shown, they shall be constructed per SMACNA Figure 4-2. Type RE1 shall be constructed with a centerline duct radius R/W of 1.0. Where shown on drawings, Type RE3 elbows with 3 vanes shall be used with centerline duct radius R/W of 0.6 (SMACNA r/W=0.1). RE1 or RE3 elbows may be used where mitered elbows are shown if space permits. **Mitered elbows (with or without turning vanes) may not be substituted for radius elbows.** Do not make branch takeoffs within 4 duct diameters on the side of the duct downstream from the inside radius of radius elbows.

5. Rectangular branch and tee connections in ducts over 1” pressure class shall be 45° entry type per Figs. 4-5 and 4-6. Rectangular straight taps are not acceptable above 1” pressure class.

6. Bellmouth fittings shown on return duct inlets shall expand at a 60-degree total angle horizontally and vertically (space permitting) and have length of at least 25% of the smallest duct dimension.

7. Round taps off rectangular unlined ducts shall be flanged conical or bellmouth type (equal to Buckley Bellmouth or Sheet Metal Connectors E-Z Tap), or 45° rectangular with transition to round (equal to Sheet Metal Connectors Inc. High Efficiency Takeoff). Straight taps are acceptable if pressure class is 1” or less, round duct is 12" diameter or less, and the tap is not located between fans and TAB devices.

8. Duct offsets shall be constructed as shown on drawings. Additional offsets required in the field shall be formed of mitered elbows without turning vanes for offsets up to 30° maximum angle in accordance with SMACNA offset Type 2. Offsets of greater than 30° angle shall be formed of radius elbows with centerline radius R/W=1.0 or greater. SMACNA Type 1 offsets are not permitted.

9. All lined duct shall utilize dovetail joints where round or conical taps occur. The dovetail joints shall extend past the liner before being folded over.

10. Cushion heads are acceptable only downstream of TAB devices in ducts up to ± 2" pressure class, and must be less than 6” in length.

11. Slide-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

    a. Apply sealant to all inside corners. Holes at corners are not acceptable.

    b. Acceptable Manufacturers: Ductmate Industries - 25/35/45, Nexus, Mez, or WDCI. Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer’s approval before any fabrication begins.

12. Formed-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

    a. Apply sealant to all inside corners. Holes at corners are not acceptable.

    b. Flanges shall be 24-gauge minimum (not 26 gauge).

    c. Acceptable Manufacturers: Lockformer TDC, TDF, United McGill, or Sheet Metal Connectors. Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer’s approval before any fabrication begins.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide openings in ducts for thermometers and controllers.

B. Locate ducts with space around equipment for normal operation and maintenance.

C. Do not install ducts or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the electrical equipment. Unless intended to serve these rooms, do not install any ductwork or equipment in electrical rooms, transformer rooms, electrical closets, telephone rooms or elevator machine rooms.

D. During construction provide temporary closures of metal or taped polyethylene on open ducts to prevent dust from entering ductwork. Supply ductwork shall be free of construction debris, and shall comply with level “B” of the SMACNA Duct Cleanliness for New Construction Guidelines.

E. Repair all duct insulation and liner tears.

F. Install manual volume dampers in branch supply ducts so all outlets can be adjusted. Do not install dampers at air terminal device or in outlets, unless specifically shown.

G. Insulate terminal air box reheat coils. Seal insulation tight to form a tight vapor barrier.

H. Install flexible duct in accordance with the ADC Flexible Duct Performance and Installation Standards.

I. Flexible duct shall NOT be joined to flat-oval connections. Provide sheet metal oval-to-round transitions where required, to include, but not limited to, all connections to air inlets, air outlets, and terminal air boxes.

J. Install all exterior ductwork per SMACNA Fig. 6-3. Where drawings do not indicate otherwise, ductwork seams and joints shall be sealed watertight and pitched to shed water.

K. Support all duct systems in accordance with the SMACNA HVAC Duct Construction Standards: Metal and Flexible.

L. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by California Building Codes.

M. Adhesives, sealants, tapes, vapor retarders, films, and other supplementary materials added to ducts, plenums, housing panels, silencers, etc. shall have flame spread/smoke developed ratings of under 25/50 per ASTM E84, NFPA 255, or UL 723.

N. Kitchen Grease and Dishwasher Ductwork:

1. All kitchen grease and dishwasher ductwork shall be installed with a continuous slope and grease tight welds on all seams and joints.

3.2 DUCTWORK APPLICATION SCHEDULE

USAGE	MATERIAL	PRESSURE CLASS	SEAL CLASS †	INSULATION
Supply Duct from Terminal Air Boxes to Outlets	Galvanized Sheet Metal - Rectangular	+2"	A	1-1/2" thick Type A (R=5.4) 2" thick Type A (R=7.1)
Return Duct	Galvanized Sheet Metal	-2"	A	None
General Exhaust Duct	Galvanized Sheet Metal	-1"	A	None or 1" thick Type C (R=3.6)
† Seal Class is per SMACNA HVAC Air Duct Leakage Test Manual				

3.3 DUCTWORK SEALING

A. General Requirements:

1. Openings, such as rotating shafts, shall be sealed with bushings or similar.

2. Pressure sensitive tape shall not be used as the primary sealant unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification.

3. All connections shall be sealed including, but not limited to, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that would void product listings is not required. Spiral lock seams need not be sealed.

4. Mastic-based duct sealants shall be applied to joints and seams in minimum 3 inch wide by 20 mil thick bands using brush, putty knife, trowel, or spray, unless manufacturer's data sheet specifies other application methods or requirements.

B. For Seal Class A ducts, all transverse joints, longitudinal seams, and duct wall penetrations shall be sealed. Joints are inclusive of, but not limited to, girth joints, branch and sub-branch intersections, duct collar tap-ins, fitting subsections, louver and air terminal connections to ducts, access door and access panel frames and jambs, duct, plenum, and casing abutments to building structures.

3.4 TESTING

A. Duct - 2" WG or Less (positive or negative):

1. Systems shall not leak more than shown in Table 4-1 of SMACNA HVAC Air Duct Leakage Test Manual for Seal Class A.

2. Leak testing of these systems is not normally required for interior ductwork. However, leak tests will be required if, in the opinion of the Architect/Engineer, the leakage appears excessive. All exterior ductwork shall be tested. If duct has outside wrap, testing shall be done before it is applied.

3. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.

4. Seal ducts to bring the air leakage into compliance.

5. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.

3.5 DUCTWORK PENETRATIONS

A. All duct penetrations of firewalls shall have fire or fire/smoke dampers where required by code.

B. Dampers shall be compatible with fire rating of wall assembly. Verify actual rating of any wall being penetrated with Architect/Engineer.

C. Seal all duct penetrations of walls that are not fire rated by caulking or packing with fiberglass. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms.

END OF SECTION

SECTION 23 34 23

POWER VENTILATORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Roof Exhaust Fans.
B. Rooftop Fan Curbs.
C. Propeller Fans.

1.2 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.
B. Sound Ratings: AMCA 301, tested to AMCA 300.
C. Fabrication: Conform to AMCA 99.

1.3 REFERENCES

A. AMCA 99 - Standards Handbook.
B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
C. AMCA 300 - Test Code for Sound Rating Air Moving Devices.
D. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.
E. NFPA-13 – The Standard for Sprinkler Installation.
F. SMACNA - HVAC Duct Construction Standards, 1995 Edition.

1.4 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include product data on wall and roof exhausters, and ceiling and cabinet fans.

B. Provide multi-rpm fan curves with specified operating point clearly plotted.

C. Submit manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 ROOFTOP EXHAUST FAN - DIRECT DRIVEN

A. Fan Wheel: Centrifugal type, aluminum hub and wheel with backward inclined blades, statically and dynamically balanced.

B. Housing: Removable, spun aluminum dome or rectangular top, with square, one piece, aluminum base and curb cap with Venturi inlet cone.

C. Construction: Fan construction shall meet the intent of AMCA 99-0401 construction requirements for Spark B.

D. Direct drive, motor mounted outside of air stream and ventilated with outside air.

E. Aluminum or brass bird screen. Plastic mesh will not be allowed.

F. Furnish factory mounted and wired disconnect switch: Non-fusible type with thermal overload protection mounted inside fan housing, factory wired through an aluminum conduit.

G. Furnish solid-state dial speed controller. Mount and wire inside fan unless shown otherwise on the drawings. Provide permanent marking at balanced point.

H. Furnish normally closed, electric motorized damper. Provide step-down transformer if required. Install and wire damper to open when fan runs.

I. Dampers shall be aluminum with brass bushings, blade seals and blade tie rods.

J. Mill aluminum finish.

K. Furnish permanently lubricated sealed ball type motor and drive shaft bearings. Motor and wheel supported by vibration isolators.

L. Acceptable Manufacturers: Aerovent "FACX", Cook "ACE-D", Greenheck, ILG – CRD, ACME PX, Penn DX, Carnes, Twin City DCRU.

2.2 ROOFTOP FAN CURBS

A. Furnish and install prefabricated roof curbs for all rooftop fans.

B. Size curb to match the curb cap of fan.

C. Top of all curbs shall be at least 12" above the top of the roof. Increase curb height to allow for roof insulation.

D. Unitized construction, continuous arc welded corner seams. Insulated with 1-1/2" thick, 3 lb. density rigid fiberglass board. Damper support angle. Pressure treated wood nailer.

E. If called for in the drawings, curbs shall be of the sound attenuation type. Sound attenuation curbs shall reduce the fan sone rating by at least 40% and not decrease fan cfmmore than 8% (which is accounted for in the scheduled fan cfm). Baffles shall be removable for access to the dampers.

F. 14-gauge aluminum construction.

G. Acceptable Manufacturers: Same manufacturer as the fan, Pate, RPS or Thy.

2.3 PROPELLER FANS

A. Direct-driven as scheduled propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.

B. Cast-aluminum blades fastened to cast-aluminum hub; factory set pitch angle of blades.

C. Construction: Fan construction shall meet the intent of AMCA 99-0401 construction requirements for Spark B.

D. Provide motor-side back guard complying with OSHA specifications, removable for maintenance.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

F. Shaft Bearings: Permanently lubricated, L_{10} of 100,000 hours, permanently sealed, self-aligning ball bearings.

G. Provide with the following accessories:

1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.

2. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

H. Acceptable Manufacturers: Aerovent, Cook, Greenheck, ACME, Penn, Carnes.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure roof exhausters with cadmium plated lag screws to roof curb.

C. If manufacturer has no recommendations, secure roof exhaust fans to curbs with 1/4” lag bolts on 8” maximum centers.

D. MC shall install and wire factory provided damper to open when the fan runs if the manufacturer does not provide an option to pre-wire the damper.

END OF SECTION

SECTION 23 74 23.13

GAS FIRED MAKE-UP AIR UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Indirect Fired Make-Up Air Unit.

1.2 QUALITY ASSURANCE

A. Comply with applicable regulations and have local Gas Company approval.

B. Factory test to check construction, controls, and operation of unit and provide certification.

C. Test operation after installation.

D. Provide with complete one (1) year warranty. Warranty period begins at date of initial startup.

E. Conform to ASHRAE 90.1.

F. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 REFERENCES

A. AGA - Directory of Certified Appliances and Accessories.
B. ANSI Z83.18 - Recirculating Direct Gas-Fired Industrial Air Heaters.
C. ANSI Z83.4 - Non-Recirculating Direct Gas-Fired Industrial Air Heaters.
D. ANSI/AGA Z223.1 - National Fuel Gas Code.
E. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.
F. FM - FM Global.
G. NFPA 70 - National Electrical Code.
H. NFPA 90A - Installation of Air Conditioning and Ventilating System.
I. UL - Underwriters' Laboratory.

1.4 SUBMITTALS

A. Submit shop drawings per Section 23 05 00 showing dimensions, connections, arrangement, accessories, electrical service and duct connections, and controls.

B. Submit manufacturer's installation instructions.

C. Submit operation and maintenance data including manufacturer's descriptive literature, maintenance and repair data, and parts listing.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect units from physical damage by storing off-site until ready for installation.

PART 2 - PRODUCTS

2.1 INDIRECT FIRED MAKE-UP AIR UNIT

A. Acceptable Manufacturers:

1. Trane
2. Sterling/Applied Air
3. Modine
4. Hastings
5. Rupp
6. Reznor

B. Manufactured Units:

1. Self-contained indirect-fired make-up air unit with burner, inlet damper, gas controls, unit controls, and all accessories noted or required for complete installation.

2. Units shall bear a UL, ETL or AGA label indicating that the units have been tested and comply with ANSI standards.

3. Pad mounted, outdoors, with weatherproofed panels and doors.

4. Unit to consist of outdoor air hood, outdoor air inlet damper, indirect-fired gas burner, unit cabinet and frame, supply fan, discharge damper, and all unit and burner safety and control devices.

5. Controls shall be unit mounted with remote panels as indicated.

6. Furnish non-fused disconnect switch, short circuit protection of all internal electrical components, and all necessary motor starters, contactors, and over-current protection.

C. Fabrication:

1. Construct heater casing and components of 18 gauge (1.21 mm) steel panels, reinforced with angles and channels for rigidity. Provide access panels to burner and blower motor assemblies.

2. Locate port on burner section for observing main and pilot flames.

3. Insulate indoor units up to burner section with 1"25 mm thick neoprene faced glass fiber insulation.

4. Finish casing and components with heat resistant baked enamel.

D. Filters:

1. Provide filter section complete with removable 1"25 mm thick glass fiber, disposable filters in metal frames.

E. Burner and Heat Exchanger:

1. Provide electronic modulating natural gas burner capable of modulating the gas input from 100% to 40% rated input. Provide with duct thermostat with remote setpoint adjustment.

2. Gas Burner: Atmospheric type burner with adjustable combustion air supply, pressure regulator, gas valves, manual shutoff, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shutoff pilot.

3. Gas Burner Safety Controls: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, energize blower motor, and after airflow proven and slight delay, allow gas valve to open.

4. High Limit Control: Temperature sensor with fixed stop at maximum permissible setting, de-energize burner on excessive bonnet temperature and energize burner when temperature drops to lower safe value.

5. Provide motorized damper with end switch to prove position before burner will fire. Inlet dampers required on indoor units. Discharge dampers required on outdoor units.

6. Provide with 20 gauge (0.95 mm), type 409, stainless steel, burners, flue collector, heat exchanger, and tubes and headers on all furnaces.

F. Fan:

1. Provide statically and dynamically balanced centrifugal fan mounted on solid steel shaft with heavy duty self-aligning lubricated ball bearings and V-belt drive.

2. All fan bearings shall have easily accessible grease fittings.

G. Unit Controls:

1. Pre-wire unit so connection of power supply and field wiring from unit to remote control panel makes unit operative. Wiring and control enclosures shall meet NEC and local codes. Provide control voltage transformers as required. All wiring shall be in conduit or in enclosures. Provide pre-wired, numbered terminal strips for field wiring connections.

2. Provide remote control panel with Summer-Off-Winter switch, indicating lights for blower on, burner on, flame failure, low temperature and clogged filter.

3. All unit controls shall be electronic type.

4. Interlock unit to run when vent damper opens and booster fan runs.

5. Provide booster fan for vent and associated wiring.

6. Provide the following safety controls: air flow switch, electronic flame safety relay, high temperature limit switch, starter interlock, high gas pressure switch, low gas pressure switch, low discharge temperature control with bypass timer.

7. Provide outdoor thermostat to lock-out burner when outdoor temperature is above 60ºF16°C (adj.).

8. Interlock unit to start when exhaust fan runs. Interlock burner to operate when flow switch in exhaust duct proves flow. Interlock wiring is by the Mechanical Contractor.

9. Unit dampers shall close whenever unit is off. Dampers shall prove open before the unit operates.

H. Discharge Temperature Controls:

1. Fixed Discharge Temperature:

a. Modulate burner to maintain a fixed discharge temperature at the unit mounted sensor.

b. Provide remote wall mounted panel for resetting discharge air temperature. Wire to unit control panel.

c. Controls shall be electronic.

d. Refer to Section 23 09 00 for additional requirements.

e. Provide relays to signal the following conditions to the DDC system:

1) Discharge air temperature drops below 50°F.

I. Gas Manifold:

1. Pilot line shall include: gas shutoff valve, gas regulator, pilot gas valve.

2. Main gas line shall include: gas shutoff valve, gas regulator, main gas valve (2 required), modulating gas valve, leakage test valve, low pressure gas switch, high pressure gas switch, vent valve between the two main gas valves and all required test valves.

3. Gas train shall meet FIA/IRI, local utility, and Owner's insurance company requirements.

4. Provide piping from vent valve to outside the building.

5. Provide additional regulator if the incoming gas pressure exceeds 2 psig15 kPa gauge.

6. Locate all valves and components in a unit mounted enclosure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that area is ready to receive work and opening dimensions are as indicated on the shop drawings and illustrated by the manufacturer.

B. Verify that proper power supply is available.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Mount units on factory-built roof mounting frame providing watertight enclosure to protect ductwork and utility services. Install roof mounting frame level.

C. All field wiring shall be per the National Electrical Code.

3.3 MANUFACTURER'S FIELD SERVICES

A. Provide initial start-up and shutdown during first year of operation, including routine servicing and check-out.

END OF SECTION

SECTION 23 81 45

VARIABLE REFRIGERANT FLOW HEAT PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Variable refrigerant flow split system heat pump (heat/cool).

B. Variable refrigerant flow split system heat pump with heat recovery (simultaneous heat/cool).

1.2 REFERENCES

A. ANSI/AHRI 210/240 – Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment.
B. ANSI/AHRI 270 - Sound Rating of Outdoor Unitary Equipment.
C. ANSI/ASHRAE 62 - Ventilation for Acceptable Indoor Air Quality.
D. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.
E. MIL-H-22547B - Heat Pump, Heating and Cooling (Unitary).

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00.

B. Indicate water, drain, and electrical rough-in connections on shop drawings or product data.

C. Submit manufacturer's installation instructions.

D. Submit manufacturer’s warranty information.

E. Submit installing contractor’s manufacturer training certification.

F. Submit refrigerant charge. Charge calculation should be based on installed piping lengths and equipment capacities.

G. VRF Piping Layout Drawings:

1. Submit detailed VRF piping layout drawings at 1/8" = 1’-0”1/100 minimum scale complete with the following information:

a. Actual pipe routing, fittings, hanger and support types, accessories, etc. with lengths and refrigerant charge noted.

b. Include insulation thickness and type of insulation.

c. Room names and numbers, ceiling types, and ceiling heights.

d. Indicate location of all beams, bar joists, etc., along with bottom of steel elevations, for each member.

2. Submit VRF piping and equipment layout drawings. Verify clearances and interferences with other trades prior to preparing drawings. IMEG will provide electronic copies of piping drawings for Contractor's use if the Contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for this submittal. Submittals shall be in accordance with Section 23 05 00.

H. Submit Controls Diagrams:

1. Wiring diagrams and layouts for each control panel showing all termination numbers.

2. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Show all interface wiring to the control system.

3. Schematic diagrams for all field sensors and controllers.

4. A schematic diagram of each controlled system. The schematics shall have all control points labeled. The schematics shall graphically show the location of all control elements in the system.

5. A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Label all terminals.

6. All installation details and any other details required to demonstrate that the system will function properly.

7. All interface requirements with other systems.

I. Sequences: Submit a complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system. **The wording of the control sequences in the submittal shall match verbatim that included in the construction documents to ensure there are no sequence deviations from that intended by the Architect/Engineer. Clearly highlight any deviations from the specified sequences on the submittals.**

J. Control System Demonstration and Acceptance: Provide a description of the proposed process, along with all reports and checklists to be used.

K. Clearly identify work by others in the submittal.

L. Quantities of items submitted may be reviewed but are the responsibility of the Contractor to verify.

1.4 DELIVERY STORAGE AND HANDLING

A. Protect finished cabinets from physical damage by leaving factory packing cases in place before installation and providing temporary covers after installation.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.6 WARRANTY

A. Installing contractor shall perform tasks required by manufacturer to ensure maximum available warranty is achieved. This will include but is not limited to:

1. System design performed by manufacturer certified designer.
2. System installation performed by manufacturer certified installer.
3. Complete system commissioning paperwork and submit to manufacturer.

B. Provide minimum five (5) year manufacturer's parts warranty (one-year basic warranty plus four-year extended warranty) on all parts (excluding compressors) and one (1) year labor warranty.

C. Provide minimum five (5) year manufacturer’s compressor parts warranty.

D. Contractor shall provide one (1) year parts and labor warranty on the associated controls system, including all devices, wiring, and programming.

1.7 DEMONSTRATION

A. Engage manufacturer or factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain individual units and complete system.

PART 2 - PRODUCTS:

2.1 ACCEPTABLE MANUFACTURERS

A. Mitsubishi
B. Daikin AC
C. Panasonic/Sanyo
D. LG
E. Toshiba Carrier

2.2 SYSTEM DESCRIPTION

A. The variable capacity, heat pump air conditioning system shall be a variable refrigerant flow split system. The system shall consist of multiple evaporators using PID control and inverter driven outdoor unit. The unit shall consist of direct expansion (DX), air-cooled heat pump air conditioning system, and variable speed driven compressor multi zone split system.

B. Outdoor Unit - General: The outdoor unit is designed specifically for use with the manufacturer’s components:

1. Refrigerant: R410A.

2. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant control. The refrigeration circuit of the outdoor unit shall consist of a compressor, motors, fans, condenser coil, electronic expansion valves, oil separators, service ports, liquid receivers, and accumulators.

3. All refrigerant lines shall be individually insulated between the outdoor and indoor units.

4. The connection ratio of the nominal capacity of indoor units to outdoor unit shall be 50-130%.

5. The sound pressure shall be no greater than 63 dBA at 4 feet1.2 meters from the outdoor unit at full load at fan height.

6. The system shall automatically restart operation after a power failure and shall not cause any settings to be lost, thus eliminating the need for re-programming.

7. The following safety devices shall be included on the outdoor unit: high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature. Oil recovery cycle shall be automatic as required to maintain oil levels at the outdoor unit.

8. The outdoor unit shall be able to operate in heating mode to -4°F dry bulb ambient temperature without additional ambient controls.

   a. Heating capacity at design condition of -15°F shall be no less than 50% of the value scheduled on the drawings

9. The outdoor unit shall have air cooled heat exchange coils constructed from copper tubing with aluminum fins. The coils shall be capable of being divided into sections to enable the outdoor unit to match the capacity required by the indoor units and to allow individual defrosting to take place as required.

10. The outdoor unit shall have at least one inverter controlled compressor and at least one high efficiency constant speed compressor, depending on scheduled capacity. The system shall use a control sequence to ensure that indoor loads are matched to the compressor capacity control.

11. The refrigeration process of the outdoor unit will be maintained by pressure and temperature sensors controlling solenoid valves, check valves, and bypass valves. The heating or cooling mode of the outdoor unit will be controlled using a combination of 2 and 3-way valves that shall reverse the cycle of the refrigerant to change the mode of the outdoor unit.

12. Unit Cabinet: The outdoor unit model shall be completely weatherproof and corrosion resistant. The outdoor unit shall be constructed from steel plate and treated with an anti-corrosive paint. Provide hail guards on all condenser coils and fans.

13. Fan:

    a. The outdoor unit shall consist of propeller type, direct-drive fan motors that have multiple speed operation via a DC inverter.

    b. The fans shall be a vertical discharge. The fan motors shall have inherent protection and permanently lubricated bearings.

    c. The fans shall be provided with fan guards.

14. Condenser Coil: The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.

15. Compressor:

    a. The variable speed compressor shall be capable of changing the speed to follow the variations in total cooling load as determined by the suction gas pressure as measured in the outdoor unit.

    b. The inverter driven compressor in each outdoor unit shall be DC, hermetically sealed, scroll type.

    c. The capacity control range shall be a minimum of 20% to 100% of total capacity.

    d. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.

    e. Oil separators shall be standard with the equipment, together with an oil balancing circuit.

    f. The compressor shall be mounted to avoid the transmission of vibration.

C. Oil Recovery System:

1. System shall be equipped with an oil recovery system to ensure stable operation with long refrigerant piping.

2. System shall be designed for proper oil return to compressor, along with distribution of oil to individual compressor.

D. Indoor Units:

1. General – Each indoor unit shall have a heat exchanger that shall be constructed from copper tubing with aluminum fins. The flow of refrigerant through the heat exchanger shall be controlled by an electronic modulating expansion valve. This valve shall be controlled by internal temperature sensors and shall be capable of controlling the variable capacity of the indoor unit between at least 25% and 100%. The units shall be shipped from the factory fully charged with dehydrated air.

2. Wall Mounted:

    a. The indoor units shall be designed for installation onto a wall within a conditioned space to be connected to a heat pump outdoor unit.

b. Acoustic Performance: The indoor units' sound pressure shall not exceed 35 dBA at low speed measured at 3.3 feet1 meter from the units.

c. Construction:

1) The indoor units shall be completely factory assembled and tested. Included in each unit is factory wiring, piping, electronic modulating expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. Each unit shall have at least one auto-swing louver for efficient air distribution, which closes automatically when the unit stops. The remote controller shall be able to set five (5) steps of discharge louver angle. The front grille shall be easily removed for washing. The discharge angle shall automatically set at the same angle as the previous operation upon restart. The condensate drain pipe shall be able to be connected to either left or right sides.

d. The indoor units shall be equipped with a return air thermistor.

e. The indoor unit shall be separately powered.

f. Unit Cabinet:

1) The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.

2) The cabinet shall be constructed of molded plastic cover with sound absorbing foamed polystyrene and polyethylene insulation.

g. Fan:

1) The fan shall be a direct-drive cross-flow type, statically and dynamically balanced with high and low fan speeds available.

2) The fan motor shall be thermally protected.

h. Filter: The return air shall be filtered by means of a washable long-life filter with mildew proof resin.

i. Coils:

1) Coils shall be of the direct expansion type, constructed from copper tubes expanded into aluminum fins to form a mechanical bond.

2) The refrigerant connections shall be flare connections and the condensate shall be coordinated with piping material specified in Section 23 21 00.

3) A condensate pump with at least 18 inches460 mm lift shall be located below the coil in the condensate pan, with a built-in high-level safety alarm to shut down the unit.

4) A thermistor shall be located on the liquid and gas line.

3. Ceiling Concealed Ducted (High Static Pressure):

a. The indoor unit shall be a built-in ceiling concealed indoor unit, high static pressure (HSP), for installation into the ceiling cavity. The unit shall be constructed of a galvanized steel casing to be connected to a heat pump outdoor unit. The indoor unit shall be manufactured for ducted horizontal discharge air, with ducted horizontal return air or bottom return air configuration (as scheduled or shown on the drawings). The external static pressure shall be as scheduled on the drawings.

b. Acoustic Performance: The indoor units' sound pressure shall not exceed 31 dBA at low speed 5 feet1.5 meters from the unit.

c. Construction:

1) The indoor unit shall be completely factory assembled and tested. The unit shall include factory wiring, piping, electronic modulating expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.

2) The indoor units shall be equipped with a return air thermistor.

3) The indoor unit shall be separately powered.

4) The switch box shall be reached from the side or bottom for ease of service and maintenance.

d. Unit Cabinet:

1) The cabinet shall be in the ceiling and ducted to the supply and return openings.

2) The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

3) The cabinet shall be factory insulated for use in unconditioned indoor spaces.

e. Fan:

1) The fan shall be direct-drive type, with statically and dynamically balanced impeller with high and low fan speeds.

2) The fan motor shall be thermally protected.

f. Filter: The return air shall be filtered by means of a washable long-life filter with mildew proof resin.

g. Coils:

1) Coils shall be of the direct expansion type, constructed from copper tubes expanded into aluminum fins to form a mechanical bond.

2) The refrigerant connections shall be flare connections, and the condensate shall be coordinated with piping material specified in Section 23 21 00.

3) A condensate pump with at least 18 inches of lift shall be located below the coil in the condensate pan, with a built-in high-level safety alarm to shut down the unit.

4) A thermistor shall be located on the liquid and gas line.

2.3 PIPING

A. Design Pressure: 450 psig.

1. Maximum Design Temperature: 250 F.

B. Piping - 4" and under.

1. Tubing: Type ACR hard drawn seamless copper tube, ASTM B280. Sizes indicated are nominal designation.

2. Joints: Brazed with silver solder.

3. Fittings: Wrought copper solder joint, ANSI B16.22.

4. Special Requirements: All tubing shall be cleaned, dehydrated, pressurized with dry nitrogen, plugged and tagged by manufacturer "for refrigeration service". During brazing operations, continuously purge the interior of the pipe with nitrogen to prevent oxide formation.

C. Insulation:

1. EPDM (NBR/PVC Blend is not permitted) elastomeric cellular foam; ANSI/ASTM C534; flexible plastic; 0.250.035 W/(m K) maximum 'K' value at 75ºF24ºC, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). If thickness required in Part 4 - Execution does not meet 25/50 flame spread/smoke developed rating, use multiple layers of a thickness that does meet 25/50 flame spread/smoke developed.

PART 3 - CONTROLS

3.1 GENERAL

A. The unit shall have controls provided with the unit by the manufacturer to perform input functions necessary to operate the system.

B. Computerized PID control shall be used to maintain room temperature within 1°F of setpoint.

C. The unit shall be equipped with a programmable drying cycle that dehumidifies while inhibiting changes in room temperature.

D. The indoor circuit board shall be wired to enable auxiliary heating when at least one of the following occurs:

1. Coil thermistor temperature drops below a factory setpoint in heating mode.
2. Outdoor temperature drops below setpoint (adj.).
3. Based on a user adjustable schedule.

3.2 SIMPLE REMOTE CONTROL – TYPE A

A. The wired remote controller shall be able to control one (1) group (maximum of 16 units) and shall be able to function as follows:

1. The controller shall have a self-diagnosis function that constantly monitors the system for malfunctions.

2. The controller shall be able to immediately display fault location and condition.

3. An LCD digital display shall allow the temperature to be set in 1°F units.

4. The controller shall be equipped with a thermostat sensor in the remote controller, making possible more comfortable room temperature control.

B. The wired remote controller shall have the following features:

1. Operation: Start/Stop, Temperature Setting, Fan Speed.

2. Monitoring: Status, malfunction flashing, malfunction content, filter sign, operation mode, temperature setting, permit/prohibit selection, fan speed, airflow direction.

3. Control Management: Field Setting Mode, Group Setting, Auto Restart.

4. The controller shall also be able to switch an external dry contact via a 12-volt DC relay (field supplied).

3.3 MAINTENANCE ACCESS

A. Provide all gateways and connection cabling for performing maintenance functions on system.

B. Provide all software and registration codes as required to allow access into advanced maintenance functions.

3.4 SEQUENCE

A. Install a remote mounted temperature sensor.

B. The thermostat shall stage heating or cooling as required to maintain space setpoint at 72°F (adj.).

C. Thermostat shall automatically change the indoor unit mode based on the space setpoint.

D. If space setpoint continues to drop once indoor unit has been changed to heating mode, the thermostat shall enable the space electric baseboard heat.

E. Control system shall have capability to control electric baseboard heat.

F. Central controller shall enable dedicated outdoor unit based on an adjustable occupancy schedule. Coordinate enable/disable function with AHU manufacturer.

3.5 SYSTEM INTEGRATION

A. The manufacturer's control system shall be capable of sending a hardwire alarm to the facility control system.

PART 4 - EXECUTION

4.1 INSTALLATION

A. Install in accordance with manufacturer's instructions. Install all piping, fittings, and insulation to meet manufacturer's requirements. Install units level and plumb. Evaporator fan components shall be installed using manufacturer's standard mounting devices securely fastened to building structure. Install and connect refrigerant tubing and fittings.

B. Installing contractor shall attend manufacturer sponsored training to obtain installation certification.

C. Installer shall supply isolation ball valves for zoned refrigerant isolation. Installer shall supply isolation ball valves with Schrader connection for isolating refrigerant charge and evacuation at each connected indoor unit and outdoor unit. Isolation ball valves, with Schrader connection, are required for instances of indoor unit isolation for troubleshooting, repair, or replacement without affecting the remainder of the system. Isolation ball valves with Schrader connection are also required at outdoor unit connection to isolate unit for troubleshooting, repair, or replacement and as required to provide partial capacity heating/cooling in the instance of a failure of one of the multiple outdoor unit compressors.

D. Insulate all refrigerant pipes between the outdoor and indoor units. This includes the liquid pipe, the suction pipe, the hot gas pipe, and the high/low pressure gas pipe. All fittings, valves, and specialty refrigerant components in the piping between the indoor and outdoor units shall also be insulated. The insulation shall have a continuous vapor barrier and shall pass through hangers and supports unbroken. Over size hangers and supports to allow the insulation to pass through unbroken. Following are the minimum insulation thicknesses unless noted otherwise in the manufacturer's literature or required by local AHJ:

Pipe System	Insulation Thickness
Refrigerant Gas (from branch selector to indoor unit)	
All sizes	1/2”
Refrigerant Suction (40ºF & Above)	
Up to 1-1/2”	1/2”
1-1/2” and up	1”
Refrigerant High/Low Pressure Gas	
Up to 1-1/2”	1”
1-1/2” and up	1-1/2”

Pipe System	Insulation Thickness
Refrigerant Liquid	
Up to 1-1/2”	1/2”
1-1/2” and up	1”

E. Engage manufacturer or factory-authorized service representative to perform startup service. Manufacturer shall provide on-site startup and commissioning assistance through job completion. Complete installation and startup checks according to manufacturer’s written instructions.

F. Fully charge system with refrigerant per manufacturer’s requirements.

G. Field Quality Control:

1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections, and to assist in field testing.

2. Perform the following field tests and inspections, and prepare test reports:

a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Coordinate installation of units with architectural and electrical work. Coordinate installation of ceiling recessed units with ceiling grid layout. Additional ceiling grid reinforcement or modification is the responsibility of the Mechanical Contractor and shall be coordinated with the General Contractor.

I. Verify locations of wall-mounted devices (such as thermostats, temperature and humidity sensors, and other exposed sensors) with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Height above finished floor shall not exceed 48”.

J. Contractor is responsible for routing all condensate drains from all indoor equipment to a nearby floor drain or standpipe. If ceiling heights or space finish does not accommodate gravity drainage, Contractor is responsible for providing a condensate pump and all electrical work required.

K. Contractor is responsible for installing VRF heat pump control system. Contractor shall coordinate with the Temperature Controls Contractor to determine extent of integration with building automation system (BAS). Equipment that is required to integrate the VRF heat pump system with the BAS is the responsibility of the VRF heat pump installing contractor. Final connections between VRF heat pump system and BAS shall be by the Temperature Controls Contractor.

END OF SECTION

SECTION 23 82 00

TERMINAL HEAT TRANSFER UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Gas Fired Low Intensity Radiant Tube Heaters.

1.2 SUBMITTALS

A. Submit shop drawings per Section 23 05 00.

B. Submit catalog data including arrangements, cross sections of cabinets, grilles, bracing, typical elevations.

C. Submit schedules of equipment and enclosures indicating length, number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, and comparison of specified to actual heat output.

D. Indicate mechanical and electrical service locations and requirements. Show deviations from scheduled products.

E. Submit manufacturers' installation instructions.

F. Manufacturer shall provide special seismic certification per OSHPD CAN 2-1708a.5 with submittal. Submittals without certification will be returned and not reviewed.

1.3 DELIVERY, STORAGE AND HANDLING

A. Protect units from physical damage by storing in protected areas and leaving factory covers in place.

1.4 REGULATORY REQUIREMENTS

A. Conform to ASHRAE 90.1.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit manufacturer's operation and maintenance data. Include operating, installation, maintenance and repair data, and parts listings.

PART 2 - PRODUCTS

2.1 GAS FIRED LOW INTENSITY RADIANT TUBE HEATERS

A. Units shall be ceiling hung, gas fired, low intensity radiant type.

B. System shall include all burner, controls, combustion tube, reflector, venting materials, hanging chains, and accessories.

C. Include the following controls: Electric room thermostat, solenoid gas valve, safety pilot valve, main gas pressure regulator, pilot gas pressure regulator, main manual shutoff, high limit switch.

D. Enameled steel control housing.

E. 4” OD 16 gauge aluminized steel finished combustion tube with high emissivity black coating.

F. Polished aluminum endcaps.

G. Provide all vents and intakes in accordance with manufacturer’s recommendations.

H. Provide aluminum reflector system for the entire length of the combustion tube.

I. Acceptable Manufacturers: Schwank, Re-Verber-Ray, Co-Ray-Vac, or Reflecto-Ray.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install all products per manufacturers' instructions.

2. Coordinate recess sizes for recessed equipment.

3. Protect units with protective covers during construction.

4. Comb all coils to repair bent fins.

B. Gas Fired Radiant Tube Heaters:

1. Hang tube heaters from building structure. Mount as high as possible unless otherwise indicated.

2. Position reflectors horizontally **OR** at 30° angles on tube heaters for maximum coverage areas.

3. Route positive pressure gas vent and combustion air from tube heater to roof terminations. Provide flex connections as required.

3.2 CLEANING

A. After construction is complete, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

B. Touch-up marred or scratched surfaces of factory-finished cabinets, with materials furnished by manufacturer.

END OF SECTION

SECTION 26 05 00

BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 26 Sections. Also refer to Division 1 - General Requirements. This section is also applicable to Interior Communications Pathways Section 27 05 28.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced in each specification section.

1.2 REFERENCES

A. NFPA 70 - National Electrical Code (NEC)

1.3 SCOPE OF WORK

A. This Specification and the associated drawings govern furnishing, installing, testing and placing into satisfactory operation the Electrical Systems.

B. The Contractor shall furnish and install all new materials as indicated on the drawings, and/or in these specifications, and all items required to make his portion of the Electrical Work a finished and working system.

C. Description of Systems shall be as follows:

1. Electrical power system to and including luminaires, equipment, motors, devices, etc.
2. Electrical power service system from the Utility Company to and including service entrance equipment, distribution and metering.
3. Grounding system.
4. Security system.
5. Wiring system for temperature control system as shown on the drawings.
6. Lightning protection system.
7. Wiring of equipment furnished by others.
8. Removal work and/or relocation and reuse of existing systems and equipment.
9. Technology Systems as described in Division 27/28 and on the T-series documents as described in the Suggested Matrix of Scope Responsibility.

D. Work Not Included:

1. Telecommunications cabling will be by others, in raceways and conduits furnished and installed as part of the Electrical work.

2. Temperature control wiring for plumbing and HVAC equipment (unless otherwise indicated) will be by other Contractors.

1.4 OWNER FURNISHED PRODUCTS

A. The Owner will supply manufacturer's installation data for new equipment purchased by him for this project.

B. This Contractor shall make all electrical system connections shown on the drawings **or** required for fully functional units.

C. This Contractor is responsible for all damage to Owner furnished equipment caused during installation.

1.5 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL, AND CONTROL CONTRACTORS

A. Division of work is the responsibility of the Prime Contractor. Any scope of work described at any location on the contract document shall be sufficient for including said requirement in the project. The Prime Contractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described on the contract documents on bid day. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Mechanical Contractors" refers to the Contractors listed in Division 21/22/23 of this Specification.

2. “Technology Contractors” refers to the Contractors furnishing and installing systems listed in Division 27/28 of this Specification.

3. Motor Power Wiring: The single phase or 3 phase wiring extending from the power source (transformer, panelboard, feeder circuits, etc.) through disconnect switches and motor controllers to, and including the connections to the terminals of the motor.

4. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case, the devices are usually single phase, have "Manual-Off-Auto" provisions, and are usually connected into the motor power wiring through a manual motor starter.

5. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.

6. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. When the motor power wiring exceeds 120 volts, a control transformer is usually used to give a control voltage of 120 volts.

7. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring that directly powers or controls a motor used to drive equipment such as fans, pumps, etc. This wiring will be from a 120-volt source and may continue as 120 volt, or be reduced in voltage (24 volt), in which case a control transformer shall be furnished as part of the temperature control wiring.

8. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.

9. Low Voltage Technology Wiring: The wiring associated with the Technology Systems, used for analog or digital signals between equipment.

10. Telecommunications Rough-in: Relates specifically to the backboxes, necessary plaster rings and other miscellaneous hardware required for the installation or mounting of telecommunications information outlets.

C. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractors' responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors, etc. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals approved. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.

2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall furnish complete wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.

3. The Electrical Contractor shall establish electrical utility elevations prior to fabrication and installation. The Electrical Contractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

a. Luminaires.
b. Gravity flow piping, including steam and condensate.
c. Electrical bus duct.
d. Sheet metal.
e. Cable trays, including access space.
f. Other piping.
g. Conduits and wireway.

D. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment furnished by the Mechanical Contractor.

2. Assumes all responsibility for miscellaneous items furnished by the Mechanical Contractor that require wiring but are not shown on the electrical drawings or specified in the Electrical Specification. If items such as relays, flow switches, or interlocks are required to make the mechanical system function correctly or are required by the manufacturer, they are the responsibility of the Mechanical Contractor.

3. Assumes all responsibility for Temperature Control wiring, if the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.

4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

E. Temperature Control Contractor's or Subcontractor's Responsibility:

1. Wiring of all devices needed to make the Temperature Control System functional.

2. Verifying any control wiring on the electrical drawings as being by the Electrical Contractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Contractor or Subcontractor.

3. Coordinating equipment locations (such as PE’s, EP’s, relays, transformers, etc.) with the Electrical Contractor, where wiring of the equipment is by the Electrical Contractor.

F. Electrical Contractor's Responsibility:

1. Furnishes and installs all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor in the Mechanical Drawings or Specifications.

2. Installs and wires all remote-control devices furnished by the Mechanical Contractor or Temperature Control Contractor when so noted on the Electrical Drawings.

3. Furnishes and installs motor control and temperature control wiring, when noted on the drawings.

4. Furnishes, installs, and connects all relays, etc., for automatic shutdown of certain mechanical equipment (supply fans, exhaust fans, etc.) upon actuation of the Fire Alarm System.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

G. General (Electrical/Technology):

1. "Electrical Contractor" as referred to herein shall be responsible for scope listed in Division 27/28 of this specification when the "Suggested Matrix of Scope Responsibility" indicated work shall be furnished and installed by the EC. Refer to the Contract Documents for this "Suggested Matrix of Scope Responsibility".

2. The purpose of these Specifications is to outline the Electrical and Technology Contractor's work responsibilities as related to Telecommunications Rough-in, conduit, cable tray, power wiring and Low Voltage Technology Wiring.

3. The exact wiring requirements for much of the equipment cannot be determined until the systems have been purchased and submittals approved. Therefore, only known wiring, conduits, raceways and electrical power related to such items is shown on the Technology drawings. Other wiring, conduits, raceways, junction boxes and electrical power not shown on the Technology Drawings but required for operation of the systems is the responsibility of the Technology Contractor and included in said Contractor's bid.

4. Where the Electrical Contractor is required to install conduit, conduit sleeves and/or power connections in support of Technology systems, the final installation shall not be until a coordination meeting between the Electrical Contractor and the Technology Contractor has convened to determine the exact location and requirements of the installation.

5. Where the Electrical Contractor is required to install cable tray that will contain Low Voltage Technology Wiring, installation shall not begin prior to a coordination review of the cable tray shop drawings by the Technology Contractor.

H. Technology Contractor's Responsibility:

1. Assumes all responsibility for the Low Voltage Technology Wiring of all systems, including cable support where open cable is specified.

2. Assumes all responsibility for all required backboxes, conduit and power connections not specifically shown as being furnished and installed by the Electrical Contractor on the "Suggested Matrix of Scope Responsibility".

3. Assumes all responsibility for providing and installing all ladder rack and other cable management hardware (as defined herein).

4. Responsible for providing the Electrical Contractor with the required grounding lugs or other hardware for each piece of Technology equipment which is required to be bonded to the telecommunications ground bar.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.6 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

   a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.

   b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5” and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

   c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5” and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

   d. Maintenance clearances and code-required dedicated space shall be included.

   e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.

2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

   a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor’s use if the contractor signs and returns an “Electronic File Transfer” waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

a. Scale of drawings:

1) General plans: 1/4 Inch = 1 '-0" (minimum).

2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).

3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).

4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1 '-0" (minimum).

5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.

3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.

4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner’s Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.

2. A plotted set of coordination drawings shall be available at the project site.

3. Coordination drawings are not shop drawings and shall not be submitted as such.

4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.

5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.

6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.

7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.

9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

    a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.

    b. Potential layout changes shall be made to avoid additional access panels.

    c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

    d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.

    e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign-off of the drawings by all contractors prior to installing any of the components.

11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.

12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.7 QUALITY ASSURANCE

A. Contractor’s Responsibility Prior to Submitting Pricing/Bid Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guides, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the

individual Contract Documents and report at once in writing to the Architect/Engineer any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.

2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor's own employees. Any work performed prior to receipt of instructions from the Architect/Engineer will be done at the Contractor's risk.

B. Qualifications:

1. Only products of reputable manufacturers as determined by the Architect/Engineer are acceptable.

2. All Contractors and subcontractors shall employ only workmen who are skilled in their trades. At all times, the number of apprentices at the job site shall be less than or equal to the number of journeymen at the job site.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the City of Madison, Wisconsin Codes, Laws, Ordinances and other regulations having jurisdiction over this installation.

2. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.

3. If the Contractor notes, at the time of bidding, any parts of the drawings or specifications that do not comply with the codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, he shall submit with his proposal a separate price to make the system comply with the codes and regulations.

4. All changes to the system made after the letting of the contract to comply with codes or the requirements of the Inspector, shall be made by the Contractor without cost to the Owner.

5. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.

6. If there are no local codes having jurisdiction, the current issue of the NEC shall be followed.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.

3. Pay all charges for permits or licenses.

4. Pay all fees and taxes imposed by State, Municipal, and other regulatory bodies.

5. Pay all charges arising out of required inspections by an authorized body.

6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.

7. Where applicable, all fixtures, equipment and materials shall be listed by Underwriter's Laboratories, Inc. or a nationally recognized testing organization.

8. Pay all telephone company charges related to the service or change in service.

E. Utility Company Requirements:

1. Secure from the private or public utility company all applicable requirements.

2. Comply with all utility company requirements.

3. The Owner shall make application for and pay for new electrical service equipment and installation. The Contractor shall coordinate schedule and requirements with the Owner and Utility Company.

4. Furnish the meter socket and metering compartment. Verify approved manufacturers and equipment with the Utility Company.

5. The Owner shall apply and pay for any changes for removal of existing electrical service by the utility company. The Contractor shall verify approved manufacturers and equipment with the Utility Company.

F. Examination of Drawings:

1. The drawings for the electrical work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.

2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of raceways to best fit the layout of the job. Conduit entry points for electrical equipment including, but not limited to, panelboards, switchboards, switchgear and unit substations, shall be determined by the Contractor unless noted in the contract documents.

3. Scaling of the drawings will not be sufficient or accurate for determining these locations.

4. Where job conditions require reasonable changes in arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

5. Because of the scale of the drawings, certain basic items, such as junction boxes, pull boxes, conduit fittings, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.

6. If an item is either shown on the drawings or called for in the specifications, it shall be included in this contract.

7. The Contractor shall determine quantities and quality of material and equipment required from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater and better-quality number shall govern.

8. Where used in electrical documents the word “furnish” shall mean supply for use, the word “install” shall mean connect up complete and ready for operation, and the word “provide” shall mean to supply for use and connect up complete and ready for operation.

9. Any item listed as furnished shall also be installed unless otherwise noted.

10. Any item listed as installed shall also be furnished unless otherwise noted.

G. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed “Electronic File Transmittal” form provided by IMEG.

4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor’s use of these documents.

H. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any conduit, conductors, wireways, bus duct, fittings, etc.

1.8 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	Submittal Item
26 05 17	Electric Heat Trace and Snow Melt
26 05 73	Power System Study
26 09 33	Lighting Control Systems
26 20 00	Service Entrance
26 22 00	Dry Type Transformers
26 24 13	Switchboards
26 24 16	Panelboards
26 24 19	Motor Control
26 27 26	Wiring Devices
26 28 16	Disconnect Switches
26 28 21	Contactors
26 41 00	Lightning Protection Systems
26 43 00	Surge Protection Devices
26 51 00	Lighting
28 31 00	Fire Alarm and Detection Systems

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

    a. Date
    b. Project title and number
    c. Contractor's name and address
    d. Division of work (e.g., electrical, plumbing, heating, ventilating, etc.)
    e. Description of items submitted and relevant specification number
    f. Notations of deviations from the contract documents
    g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

    a. Date
    b. Project title and number
    c. Architect/Engineer
    d. Contractor and subcontractors' names and addresses
    e. Supplier and manufacturer's names and addresses
    f. Division of work (e.g., electrical, plumbing, heating, ventilating, etc.)
    g. Description of item submitted (using project nomenclature) and relevant specification number
    h. Notations of deviations from the contract documents
    i. Other pertinent data
    j. Provide space for Contractor's review stamps

3. Composition:

    a. Submittals shall be submitted using specification sections and the project nomenclature for each item.

b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).

c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

5. Contractor’s Approval Stamp:

a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.

b. Unstamped submittals will be rejected.

c. The Contractor’s review shall include, but not be limited to, verification of the following:

1) Only approved manufacturers are used.
2) Addenda items have been incorporated.
3) Catalog numbers and options match those specified.
4) Performance data matches that specified.
5) Electrical characteristics and loads match those specified.
6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
7) Dimensions and service clearances are suitable for the intended location.
8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

d. The Contractor shall review, stamp and approve all subcontractors’ submittals as described above.

e. **The Contractor’s approval stamp is required on all submittals. Approval will indicate the Contractor’s review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.**

6. Submittal Identification and Markings:

   a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.

   b. The Contractor shall clearly indicate the size, finish, material, etc.

   c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.

   d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.

8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.

9. Reproduction of contract documents alone is not acceptable for submittals.

10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.

11. Submittals not required by the contract documents may be returned without review.

12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.

13. Submittals shall be reviewed and approved by the Architect/Engineer **before** releasing any equipment for manufacture or shipment.

14. Contractor’s responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer’s approval.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. Submittal file name: 26 XX XX.description.YYYYMMDD
    b. Transmittal file name: 26 XX XX.description.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be transmitted via a pre-approved method.

1.9 SCHEDULE OF VALUES

A. The requirements herein are in addition to the provisions of Division 1.

B. Format:

1. Use AIA Document Continuation Sheets G703 or another similar form approved by the Owner and Architect/Engineer.
2. Submit in Excel format.
3. Support values given with substantiating data.

C. Preparation:

1. Itemize work required by each specification section and list all providers. All work provided by subcontractors and major suppliers shall be listed on the Schedule of Values. List each subcontractor and supplier by company name.

2. Break down all costs into:

    a. Material: Delivered cost of product with taxes paid.
    b. Labor: Labor cost, excluding overhead and profit.

D. Update Schedule of Values when:

1. Indicated by Architect/Engineer.
2. Change of subcontractor or supplier occurs.
3. Change of product or equipment occurs.

1.10 CHANGE ORDERS

A. A detailed material and labor takeoff shall be prepared for each change order, along with labor rates and markup percentages. Change orders with inadequate breakdown will be rejected.

B. Change order work shall not proceed until authorized.

1.11 PRODUCT DELIVERY, STORAGE, HANDLING AND MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage.

B. Keep all materials clean, dry and free from damaging environments.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Electrical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate his/her work with other trades.

1.12 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.13 WARRANTY

A. Provide one-year warranty for all fixtures, equipment, materials, and workmanship.

B. The warranty period for all work in this specification Division shall commence on the date of Substantial Completion or successful system performance whichever occurs later. The warranty may also commence if a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization of the Owner. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner.

C. Warranty requirements extend to correction, without cost to the Owner, of all work found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage due to defects or nonconformance with contract documents excluding repairs required as a result of improper maintenance or operation, or of normal wear as determined by the Architect/Engineer.

1.14 INSURANCE

A. This Contractor shall maintain insurance coverage as set forth in Division 1 of these specifications.

1.15 MATERIAL SUBSTITUTION

A. Where several manufacturers' names are given, the manufacturer for which a catalog number is given is the basis of design and establishes the quality required.

B. Equivalent equipment manufactured by the other named manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meet all requirements of the drawings and specifications, and fit in the allocated space. The Architect/Engineer shall make the final determination of whether a product is equivalent.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer via addendum. The Contractor assumes all costs incurred as a result of using the offered material, article or equipment, on his part or on the part of other Contractors whose work is affected.

D. Voluntary add or deduct prices for alternate materials may be listed on the bid form. These items will not be used in determining the low bidder. This Contractor assumes all costs incurred as a result of using the offered material or equipment on his part or on the part of other Contractors whose work is affected.

E. All material substitutions requested after the final addendum must be listed as voluntary changes on the bid form.

PART 2 - PRODUCTS

2.1 GENERAL

A. All items of material having a similar function (e.g., safety switches, panelboards, switchboards, contactors, motor starters, dry type transformers) shall be of the same manufacturer unless specifically stated otherwise on drawings or elsewhere in specifications.

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or his or her employees and subconsultants at a construction site, shall relieve the Contractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer’s consultants shall be indemnified and shall be made additional insureds under the Contractor’s general liability insurance policy.

3.2 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found by calling 811.

2. The Contractor shall do all excavating, filling, backfilling, compacting, and restoration in connection with his work.

B. Excavation:

1. Make all excavations to accurate, solid, undisturbed earth, and to proper dimensions.

2. If excavations are carried in error below indicated levels, concrete of same strength as specified for the foundations or thoroughly compacted sand-gravel fill, as determined by the Architect/Engineer shall be placed in such excess excavations under the foundation. Place thoroughly compacted, clean, stable fill in excess excavations under slabs on grade, at the Contractor's expense.

3. Trim bottom and sides of excavations to grades required for foundations.

4. Protect excavations against frost and freezing.

5. Take care in excavating not to damage surrounding structures, equipment or buried pipe. Do not undermine footing or foundation.

6. Perform all trenching in a manner to prevent cave-ins and risk to workmen.

7. Where original surface is pavement or concrete, the surface shall be saw cut to provide clean edges and assist in the surface restoration.

8. If satisfactory bearing soil is not found at the indicated levels, immediately notify the Architect/Engineer or their representative, and do no further work until the Architect/Engineer or their representative gives further instructions.

9. Excavation shall be performed in all ground conditions, including rock, if encountered. Bidders shall visit the premises and determine the soil conditions by actual observations, borings, or other means. The cost of all such inspections, borings, etc., shall be borne by the bidder.

10. If a trench is excavated in rock, a compacted bed with a depth of 3" (minimum) of sand and gravel shall be used to support the conduit unless masonry cradles or encasements are used.

11. Mechanical excavation of the trench to line and grade of the conduit or to the bottom level of masonry cradles or encasements is permitted, unless otherwise indicated on the electrical drawings.

12. Mechanical excavation of the trench to line and grade where direct burial cables are to be installed is permitted provided the excavation is made to a depth to permit installation of the cable on a fine sand bed at least 3 inches deep.

C. Dewatering:

1. Furnish, install, operate and remove all dewatering pumps and pipes needed to keep trenches and pits free of water.

D. Underground Obstructions:

1. Known underground piping, conduit, feeders, foundations, and other obstructions in the vicinity of construction are shown on the drawings. Review all Bid Documents for all trades on the project to determine obstructions indicated. Take great care in making installations near underground obstructions.

2. If objects not shown on the drawings are encountered, remove, relocate, or perform extra work as directed by the Architect/Engineer.

E. Fill and Backfilling:

1. No rubbish or waste material is permitted for fill or backfill.

2. Furnish all necessary sand for backfilling.

3. Dispose of the excess excavated earth as directed.

4. Backfill materials shall be suitable for required compaction, clean and free of perishable materials, frozen earth, debris, earth with a high void content, and stones greater than 4 inches in diameter. Water is not permitted to rise in unbackfilled trenches.

5. Backfill all trenches and excavations immediately after installing of conduit, or removing forms, unless other protection is directed.

6. Around piers and isolated foundations and structures, backfill and fill shall be placed and consolidated simultaneously on all sides to prevent wedge action and displacement. Spread fill and backfill materials in 6" uniform horizontal layers with each layer compacted separately to required density.

7. For conduits that are not concrete encased, lay all conduits on a compacted bed of sand at least 3" deep. Backfill around conduits with sand, in 6" layers and compact each layer.

8. Backfill with sand up to grade for all conduits under slabs or paved areas. All other conduits shall have sand backfill to 6" above the top of the conduit.

9. Place all backfill above the sand in uniform layers not exceeding 6" deep. Place then carefully and uniformly tamp each layer to eliminate lateral or vertical displacement.

10. Where the fill and backfill will ultimately be under a building, floor or paving, each layer of fill shall be compacted to 95% of the maximum density as determined by AASHTO Designation T-99 or ASTM Designation D-698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content as determined by AASHTO T-99 or ASTM D-698 test.

11. After backfilling of trenches, no superficial loads shall be placed on the exposed surface of the backfill until a period of 48 hours has elapsed.

F. Surface Restoration:

1. Where trenches are cut through graded, planted or landscaped areas, the areas shall be restored to the original condition. Replace all planting and landscaping features removed or damaged to its original condition. At least 6” of topsoil shall be applied where disturbed areas are to be seeded or sodded. All lawn areas shall be sodded unless seeding is called out in the drawings or specifications.

2. Concrete or asphalt type pavement, seal coat, rock, gravel or earth surfaces removed or damaged shall be replaced with comparable materials and restored to original condition. Broken edges shall be saw cut and repaired as directed by Architect/Engineer.

3.3 ARCHITECT/ENGINEER OBSERVATION OF WORK

A. The contractor shall provide seven (7) calendar days’ notice to the Architect/Engineer prior to:

1. Placing fill over underground and underslab utilities.

2. Covering exterior walls, interior partitions and chases.

3. Installing hard or suspended ceilings and soffits.

B. The Architect/Engineer will review the installation and provide a written report noting deficiencies requiring correction. The contractor’s schedule shall account for these reviews and show them as line items in the approved schedule.

C. Above-Ceiling Final Observation:

1. All work above the ceilings must be complete prior to the Architect/Engineer’s review. This includes, but is not limited to:

a. All junction boxes are closed and identified in accordance with Section 26 05 53 Electrical Identification.

b. Luminaires, including ceiling-mounted exit and emergency lights, are installed and operational.

c. Luminaire whips are supported above the ceiling.

d. Conduit identification is installed in accordance with Section 26 05 53 Electrical Identification.

e. Luminaires are suspended independently of the ceiling system when required by these contract documents.

f. All wall penetrations have been sealed.

2. To prevent the Above-Ceiling Final Observation from occurring too early, the Contractor shall review the status of the work and certify, in writing, that the work is ready for the Above-Ceiling Final Observation.

3. It is understood that if the Architect/Engineer finds the ceilings have been installed prior to this review and prior to seven days elapsing, the Architect/Engineer may not recommend further payments to the contractor until full access has been provided.

3.4 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. To prevent the Final Jobsite Observation from occurring too early, the Contractor shall review the completion status of the project and certify that the job is ready for the final jobsite observation.

2. Attached to the end of this section is a typical list of items that represent the degree of job completeness expected prior to requesting a review. The Contractor shall sign the attached certification and return it to the Architect/Engineer so that the final observation can be scheduled.

3. It is understood that if the Architect/Engineer finds the job not ready for the final observation and additional trips and observations are required to bring the project to completion, the cost of the additional time and expenses incurred by the Architect/Engineer will be deducted from the Contractor's final payment.

4. Contractor shall notify Architect/Engineer 48 hours prior to installation of ceilings or lay-in ceiling tiles.

C. The following must be submitted before Architect/Engineer recommends final payment:

1. Operation and maintenance manuals with copies of approved shop drawings.

2. Record documents including reproducible drawings and specifications.

3. A report documenting the instructions given to the Owner's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of this Contractor and shall be signed by the Owner's representatives.

4. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site and place in location as directed and submit receipt to Architect/Engineer.

5. Start-up reports on all equipment requiring a factory installation or start-up.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.

2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. O&M file name: O&M.div23.contractor.YYYYMMDD
   b. Transmittal file name: O&Mtransmittal.div23.contractor.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be divided into files that are clearly labeled as “1 of 2”, “2 of 2”, etc.

6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title “Operation and Maintenance Instructions”, title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.

7. All text shall be searchable.

8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.

2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.

3. Copies of all final <u>approved</u> shop drawings and submittals. Include Architect’s/Engineer’s shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.

4. Copies of all factory inspections and/or equipment startup reports.

5. Copies of warranties.

6. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.

7. Dimensional drawings of equipment.

8. Detailed parts lists with lists of suppliers.

9. Operating procedures for each system.

10. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.

11. Repair procedures for major components.

12. Replacement parts and service material requirements for each system and the frequency of service required.

13. Instruction books, cards, and manuals furnished with the equipment.

14. Include record drawings of the one-line diagrams for each major system. The graphic for each piece of equipment shown on the one-line diagram shall be an active link to its associated Operation & Maintenance data.

15. Copies of all panel schedules in electronic Microsoft Excel spreadsheet (.xlsx) file. Each panelboard shall be a separate tab in the workbook.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVE

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The instructions shall include:

1. Maintenance of equipment.
2. Start-up procedures for all major equipment.
3. Description of emergency system operation.

E. Notify the Architect/Engineer of the time and place for the verbal instructions to the Owner's representative so his representative can be present if desired.

F. Minimum hours of instruction time for each item and/or system shall be as indicated in each individual specification section.

G. Operating Instructions:

1. Contractor is responsible for all instructions to the Owner's representatives for the electrical and specialized systems.

2. If the Contractor does not have staff that can adequately provide the required instructions, he shall include in his bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 RECORD DOCUMENTS

A. The following paragraphs supplement the requirements of Division 1.

B. Maintain at the job site a separate and complete set of electrical drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.

C. Mark drawings and specifications to indicate approved substitutions; Change Orders, and actual equipment and materials used. <u>All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents</u>. Record documents that merely reference the existence of the above items are not acceptable. Should this Contractor fail to complete Record Documents as required by this contract, this Contractor shall reimburse Architect/Engineer for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at the Architect/Engineer's hourly rates in effect at the time of work.

D. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

E. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

3.8 PAINTING

A. Paint all equipment that is marred or damaged prior to the Owner's acceptance. Paint and color shall match original equipment paint and shall be obtained from the equipment supplier if available. All equipment shall have a finished coat of paint applied unless specifically allowed to be provided with a prime coat only.

B. Equipment in finished areas that will be painted to match the room decor will be painted by others. Should this Contractor install equipment in a finished area after the area has been painted, he shall have the equipment and all its supports, hangers, etc., painted to match the room decor. Painting shall be performed as described in project specifications.

C. Equipment cabinets, casings, covers, metal jackets, etc., located in equipment rooms or concealed spaces, shall be furnished in standard finish, free from scratches, abrasions, chippings, etc.

D. Equipment in occupied spaces, or if standard to the unit, shall have a baked primer with baked enamel finish coat free from scratches, abrasions, chipping, etc. If color option is specified or is standard to the unit, verify with the Architect his color preference before ordering.

E. Paint all equipment in unfinished areas such as boiler room, mechanical spaces, and storage rooms. Equipment furnished with a suitable factory finish need not be painted; provided the factory applied finish is not marred or spattered. If so, equipment shall be refinished with the same paint as was factory applied.

F. All electrical conduit and equipment, fittings, hangers, structural supports, etc., in unfinished areas, such as equipment and storage room area, shall be painted two (2) coats of oil paint of colors selected by the Architect.

G. Do NOT paint electric conduits in crawl spaces, tunnels, or spaces above suspended ceilings except that where conduit is in a damp location give exposed threads at joints two coats of sealer after joint is made up.

H. After surfaces have been thoroughly cleaned and are free of oil, dirt or other foreign matter, paint all raceway and equipment with the following:

1. Bare Metal Surfaces - Apply one coat of metal primer suitable for the metal being painted. Finish with two coats of Alkyd base enamel paint.

2. Plastic Surfaces - Paint plastic surfaces with two coats of semi-gloss acrylic latex paint.

3.9 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project.

B. Clean all foreign paint, grease, oil, dirt, labels, stickers, etc. from all equipment.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.10 SPECIAL REQUIREMENTS

A. Coordinate the installation of all equipment, controls, devices, etc., with other trades to maintain clear access area for servicing.

B. Install all equipment to maximize access to parts needing service or maintenance. Review the final location, placement, and orientation of equipment with the Owner’s representative prior to setting equipment.

C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with the Owner’s representative will result in removal and reinstallation of the equipment at the Contractor’s expense.

3.11 INDOOR AIR QUALITY (IAQ) MAINTENANCE FOR OCCUPIED FACILITIES UNDER CONSTRUCTION

A. Within the limits of Construction:

1. The Electrical Contractor shall coordinate all work with the contractor responsible for IAQ.

2. The means, methods and materials used by the Electrical Contractor shall be coordinated with the contractor responsible for IAQ and shall comply with the IAQ requirements set forth in Division 1 and Division 21/22/23 of these specifications.

B. Outside the limits of Construction:

1. IAQ shall be the responsibility of the electrical contractor for work that is required outside the limits of construction.

2. The Electrical Contractor is responsible for the IAQ set forth in Division 1 and Division 21/22/23 of these specifications.

3. The Electrical Contractor shall review and coordinate all IAQ plans and procedures with the owner's IAQ representative.

3.12 SYSTEM STARTING AND ADJUSTING

A. The electrical systems shall be complete and operating. System startup, testing, adjusting, and balancing to obtain satisfactory system performance is the responsibility of the Contractor. This includes all calibration and adjustment of electrical controls, balancing of loads, troubleshooting and verification of software, and final adjustments that may be needed.

B. Complete all manufacturer-recommended startup procedures and checklists to verify proper equipment operation and does not pose a danger to personnel or property.

C. All operating conditions and control sequences shall be tested during the start-up period. Testing all interlocks, safety shut-downs, controls, and alarms.

D. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.13 FIELD QUALITY CONTROL

A. General:

1. Conduct all tests required during and after construction. Submit test results in NETA format, or equivalent form, that shows the test equipment used, calibration date, tester's name, ambient test conditions, humidity, conductor length, and results corrected to 40°C.

2. Supply necessary instruments, meters, etc., for the tests. Supply competent technicians with training in the proper testing techniques.

3. All cables and wires shall be tested for shorts and grounds following installation and connection to devices. Replace shorted or grounded wires and cables.

4. Any wiring device, electrical apparatus or luminaire, if grounded or shorted on any integral "live" part, shall have all defective parts or materials replaced.

5. Test cable insulation of service and panel feeder conductors for proper insulation values. Tests shall include the cable, all splices, and all terminations. Each conductor shall be tested and shall test free of short circuits and grounds and have an insulation value not less than NEC Standards. Take readings between conductors, and between conductors and ground.

6. If the results obtained in the tests are not satisfactory, make adjustments, replacements, and changes as needed. Then repeat the tests, and make additional tests, as the Architect/Engineer or authority having jurisdiction deems necessary.

B. Ground Resistance:

1. Conduct service ground resistance tests using an approved manufactured ground resistance meter. Submit to the Architect/Engineer a proposed test procedure including type of equipment to be used. (The conventional ohmmeter is not an acceptable device.)

2. Make ground resistance measurements during normal dry weather and not less than 48 hours after a rain.

3. If the ground resistance value obtained is more than the value set forth in Section 26 05 26, the following shall be done to obtain the value given:

   a. Verify that all connections in the service ground system are secure.

   b. Increase the depth to which ground rods are driven by adding section lengths to the rods and retest. If the resistance is still excessive increase the depth by adding an additional rod section and retest.

   c. If the resistance is still excessive, furnish and install additional ground rods, spaced not less than 20 feet from other ground rods unless otherwise noted on plans, and connect into the ground electrode system. Retest.

   d. Review results with the Architect/Engineer.

4. Before final payment is made to the Contractor submit a written report to the Architect/Engineer including the following:

   a. Date of test.

   b. Number of hours since the last rain.

   c. Soil condition at the time of the test in the ground electrode location. That is: dry, wet, moist, sand, clay, etc.

   d. Diagram of the test set-up showing distances between test equipment, ground electrode, auxiliary electrodes, etc.

   e. Make, model, and calibration date of test equipment.

   f. Tabulation of measurements taken and calculations made.

C. Other Equipment:

1. Give other equipment furnished and installed by the Contractor all standard tests normally made to assure that the equipment is electrically sound, all connections properly made, phase rotation correct, fuses and thermal elements suitable for protection against overloads, voltage complies with equipment nameplate rating, and full load amperes are within equipment rating.

D. If any test results are not satisfactory, make adjustments, replacements and changes as needed and repeat the tests and make additional tests as the Architect/Engineer or authority having jurisdiction deem necessary.

E. Contractor shall thermographic study all electrical gear, switchboard, panelboards, etc. at the end of construction to identify any unusual conditions/heating within the equipment. Coordinate with Owner/Architect/Engineer to have an Owner/Architect/Engineer representative present during testing.

F. Report shall include color printouts, in binder, of pictures taken to use as a baseline reading after building is occupied.

G. Upon completion of the project, the Contractor shall provide amperage readings for all panelboards and switchboards and turn the results over to the Owner for “benchmark” amperages.

3.14 CONSTRUCTION WASTE MANAGEMENT

A. This Contractor shall comply with all construction and demolition waste disposal and recycling requirements outlined in LEED MRc2: Construction Waste Management (follow latest edition at the time of bidding or as referenced in these specifications).

1. This Contractor shall coordinate with the General Contractor to develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on-site or co-mingled.

2. The Contractor shall track waste disposal and recycling efforts throughout the construction process for all materials associated with this Contractor’s scope of work. The Contractor shall provide this information to the General Contractor so that it can be incorporated with similar information from all other contractors for the project.

a. Calculations for waste and recycled material can be done by weight or volume, but they must be consistent throughout the project. The Contractor shall coordinate with the General Contractor to establish the preferred calculation method and report the results accordingly.

b. Excavated soil and land-clearing debris do not count towards the waste disposal or recycled material.

3.15 UTILITY REBATE

A. Submit utility rebate forms, where offered at project location, with rebate items completed. Rebate may include lighting, lighting controls, variable speed drives, heat pumps, package terminal A/C, air conditioners, chillers, water heaters, programmable thermostats, and motors.

B. Contractor must submit notification of any value engineering or product substitution that will affect the utility rebate amount prior to approval.

END OF SECTION

READINESS CERTIFICATION PRIOR TO FINAL JOBSITE OBSERVATION

To prevent the final job observation from occurring too early, we require that the Contractor review the completion status of the project and, by copy of this document, certify that the job is indeed ready for the final job observation. The following is a typical list of items that represent the degree of job completeness expected prior to your requesting a final job observation.

1. Penetrations of fire-rated construction fire sealed in accordance with specifications.
2. Electrical panels have typed circuit identification.
3. Per Section 26 05 00, cable insulation test results have been submitted.
4. Per Section 26 05 00, ground resistance test results have been submitted.
5. Operation and Maintenance manuals have been submitted as per Section 26 05 00.
6. Bound copies of approved shop drawings have been submitted as per Section 26 05 00.
7. Report of instruction of Owner’s representative has been submitted as per Section 26 05 00.
8. Start-up reports from factory representative have been submitted as per Section 26 05 00.

Accepted by:

Prime Contractor ____

By ________________________________ Date __________________

Upon Contractor certification that the project is complete and ready for a final job observation, we require the Contractor to sign this agreement and return it to the Architect/Engineer so that the final observation can be scheduled.

It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineers for additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

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SECTION 26 05 03

THROUGH PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Through-Penetration Firestopping.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified in this Section.

B. Installer: Individuals performing work shall be certified by the manufacturer of the system selected for installation.

1.3 REFERENCES

A. UL 723 - Surface Burning Characteristics of Building Materials
B. ANSI/UL 1479 - Fire Tests of Through Penetration Firestops
C. UL Fire Resistance Directory Through Penetration Firestop Systems (XHEZ)
D. Intertek / Warnock Hersey - Directory of Listed Products
E. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials
F. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Firestops
G. Wisconsin Administrative Code

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store, protect and handle products on site. Accept material on site in factory containers and packing. Inspect for damage. Protect from deterioration or damage due to moisture, temperature changes, contaminants, or other causes. Follow manufacturer’s instructions for storage.

B. Install material prior to expiration of product shelf life.

1.5 PERFORMANCE REQUIREMENTS

A. General: For penetrations through the following fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

1. Fire-resistance-rated walls including fire partitions, fire barriers, and smoke barriers.
2. Fire-resistance-rated horizontal assemblies including floors, floor/ceiling assemblies, and ceiling membranes of roof/ceiling assemblies.

B. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per UL 1479:

1. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.
2. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings**:**

   a. Floor penetrations located outside wall cavities.
   b. Floor penetrations located outside fire-resistance-rated shaft enclosures.

3. L-Rated Systems: Provide through-penetration firestop systems with L-ratings of not more than 5.0 cfm/sq.ft. (0.0254 cu. m/s x sq. m) at both ambient temperature and 400°F (204°C) for smoke barriers.

C. For through-penetration firestop systems exposed to light, traffic, moisture, or physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

D. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

E. For through-penetration firestop systems in air plenums, provide products with flame-spread and smoke-developed indexes of less than 25 and 50, respectively, as determined per ASTM E 84.

F. In accordance with LEED EQc4.1, Low-Emitting Materials - Adhesives and Sealants, all adhesives and sealants used on the interior of the building must comply with the following requirements:

1. Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168.

2. Aerosol adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000.

1.6 MEETINGS

A. Pre-installation meeting: A pre-installation meeting shall be scheduled and shall include the General Contractor, all Subcontractors associated with the installation of systems penetrating fire barriers, Firestopping Manufacturer's Representative, and the Owner.

1. Review foreseeable methods related to firestopping work.

2. Tour representative areas where firestopping is to be installed; inspect and discuss each type of condition and each type of substrate that will be encountered, and preparation to be performed by other trades.

1.7 WARRANTY

A. Provide one year warranty on parts and labor.

B. Warranty shall cover repair or replacement of firestop systems which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability, or appear to deteriorate in any manner not clearly specified by the manufacturer as an inherent quality of the material.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the through-penetration firestop systems indicated for each application that are produced by one of the following manufacturers. All firestopping systems installed shall be provided by a single manufacturer.

1. 3M; Fire Protection Produces Division.
2. Hilti, Inc.
3. RectorSeal Corporation, Metacaulk.
4. Tremco; Sealant/Weatherproofing Division.
5. Johns-Manville.
6. Specified Technologies Inc. (S.T.I.)
7. Spec Seal Firestop Products
8. AD Firebarrier Protection Systems
9. Wiremold/Legrand: FlameStopper

2.2 THROUGH PENETRATION FIRESTOP SYSTEMS

A. Provide materials and systems classified by or listed by Intertek / Warnock Hersey to provide firestopping equal to time rating of construction being penetrated.

B. All firestopping materials shall be free of asbestos, lead, PCB’s, and other materials that would require hazardous waste removal.

C. Firestopping shall be flexible to allow for normal penetrating item movement due to expansion and contraction.

D. Provide firestopping systems capable of supporting floor loads where systems are exposed to possible floor loading or traffic.

E. Provide firestopping systems allowing continuous insulation for all insulated pipes.

F. Provide firestopping systems classified by UL or listed by Intertek / Warnock Hersey for penetrations through all fire rated construction. Firestopping systems shall be selected from the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory Category XHEZ based on substrate construction and penetrating item size and material and shall fall within the range of numbers listed:

1. Combustible Framed Floors and Chase Walls - 1 or 2 Hour Rated
F Rating = Floor/Wall Rating
T Rating = Floor/Wall Rating

Penetrating Item	UL System No.
No Penetrating Item	FC 0000-0999*
Metallic Pipe or Conduit	FC 1000-1999
Non-Metallic Pipe or Conduit	FC 2000-2999
Electrical Cables	FC 3000-3999
Cable Trays	FC 4000-4999
Insulated Pipes	FC 5000-5999
Bus Duct and Misc. Electrical	FC 6000-6999
Duct without Damper and Misc. Mechanical	FC 7000-7999
Multiple Penetrations	FC 8000-8999

2. Non-Combustible Framed Walls - 1 or 2 Hour Rated
F Rating = Wall Rating
T Rating = 0

Penetrating Item	UL System No.
No Penetrating Item	WL 0000-0999*
Metallic Pipe or Conduit	WL 1000-1999
Non-Metallic Pipe or Conduit	WL 2000-2999
Electrical Cables	WL 3000-3999
Cable Trays	WL 4000-4999
Insulated Pipes	WL 5000-5999
Bus Duct and Misc. Electrical	WL 6000-6999
Duct without Damper and Misc. Mechanical	WL 7000-7999
Multiple Penetrations	WL 8000-8999

3. Concrete or Masonry Floors and Walls - 1 or 2 Hour Rated
F Rating = Wall/Floor Rating
T Rating (Floors) = Floor Rating

Penetrating Item	UL System No.
No Penetrating Item	CAJ 0000-0999*
Metallic Pipe or Conduit	CAJ 1000-1999
Non-Metallic Pipe or Conduit	CAJ 2000-2999
Electrical Cables	CAJ 3000-3999
Cable Trays	CAJ 4000-4999
Insulated Pipes	CAJ 5000-5999
Bus Duct and Misc. Electrical	CAJ 6000-6999
Duct without Damper and Misc. Mechanical	CAJ 7000-7999
Multiple Penetrations	CAJ 8000-8999

*Alternate method of firestopping is patching opening to match original rated construction.

G. Any opening in walls or floors not covered by the listed series of numbers shall be coordinated with the firestopping manufacturer.

H. Any openings in floors or walls not described in the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory, or outlined in manufacturer's information shall be sealed in a manner agreed upon by the Firestopping Manufacturer, Owner, and the Authority Having Jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Ensure all surfaces that contact seal materials are free of dirt, dust, grease, oil, rust, or loose materials. Clean and repair surfaces as required. Remove laitance and form-release agents from concrete.

B. Ensure substrate and penetrating items have been permanently installed prior to installing firestopping systems. Ensure penetrating items have been properly spaced and have proper clearance prior to installing firestopping systems.

C. Surfaces to which sealing materials are to be installed must meet the selected UL or Intertek / Warnock Hersey system substrate criteria.

D. Prime substrates where recommended in writing by through-penetration firestop system manufacturer. Confine primer to area of bond.

3.2 INSTALLATION

A. In existing construction, provide firestopping of openings prior to and after installation of penetrating items. Remove any existing coatings on surfaces prior to firestopping installation. Temporary firestopping shall consist of packing openings with fire resistant mineral wool for the full thickness of substrate, or an alternate method approved by the Authority Having Jurisdiction. All openings shall be temporarily firestopped immediately upon their installation and shall remain so until the permanent UL or listed by Intertek / Warnock Hersey listed firestopping system is installed.

B. Install penetration seal materials in accordance with printed instructions of the UL or Intertek / Warnock Hersey Fire Resistance Directory and with the manufacturer's printed application instructions.

C. Install dams as required to properly contain firestopping materials within openings and as required to achieve required fire resistance rating. Remove combustible damming after appropriate curing.

3.3 CLEANING AND PROTECTING

A. Clean excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not cause damage.

B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.

3.4 INSPECTION

A. All penetrations shall be inspected by the manufacturer's representative to ensure proper installation.

B. Access to firestop systems shall be maintained for examination by the Authority Having Jurisdiction at their request.

C. Proceed with enclosing through-penetration firestop system with other construction only after inspection reports are issued and firestop installations comply with requirements.

D. The contractor shall allow for visual destructive review of 5% of installed firestop systems (minimum of one) to prove compliance with specifications and manufacturer's instructions and details. Destructive system removal shall be performed by the contractor and witnessed by the Architect/Engineer and manufacturer's factory representative. The Architect/Engineer shall have sole discretion of which firestop system installations will be reviewed. The contractor is responsible for all costs associated with this requirement including labor and material for removing and replacing the installed firestop system. If any firestop system is found to not be installed per manufacturer's specific instructions and details, all firestop systems are subject to destructive review and replacement at the Architect/Engineer's discretion and the contractor's expense.

END OF SECTION

SECTION 26 05 13

WIRE AND CABLE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Building wire
B. Remote control and signal cable
C. Fire rated cable and assemblies
D. Healthcare facilities cable (HFC)
E. Armored cable (AC)
F. Metal-clad cable (MC)
G. Nonmetallic-sheathed cable (NM)

1.2 RELATED WORK

A. Section 26 05 53 – Electrical Identification: Refer to electrical identification for color and identification labeling requirements.

1.3 REFERENCES

A. NEMA WC 70 - Power Cables Rated 2,000V or Less for the Distribution of Electrical Energy

B. NFPA 70 - National Electrical Code (NEC)

C. UL 44 – Thermoset-Insulated Wires and Cables

D. UL 83 – Thermoplastic-Insulated Wires and Cables

E. UL 854 – Service-Entrance Cables

F. UL 1581 – Standard for Electrical Wires, Cables, and Flexible Cords

G. UL 2196 – Fire Resistive, Fire Resistant and Circuit Integrity Cables

PART 2 - PRODUCTS

2.1 BUILDING WIRE

A. Feeders and Branch Circuits Larger Than 6 AWG: Copper, stranded conductor, 600-volt insulation, THHN/THWN or XHHW-2.

B. Feeders and Branch Circuits Larger Than 6 AWG in Underground Conduit: Copper, stranded conductor, 600-volt insulation, XHHW-2.

C. Feeders and Branch Circuits 6 AWG and Smaller: Copper conductor, 600-volt insulation, THHN/THWN. 6 and 8 AWG, stranded conductor; smaller than 8 AWG, solid or stranded conductor, unless otherwise noted on the drawings.

D. Three conductor stranded copper, 600-volt XHHW-2 insulation, with copper ground andoverall helical copper tape shield. Shield shall be terminated at both ends of cable with an approved termination.

E. Control Circuits: Copper, stranded conductor 600-volt insulation, THHN/THWN.

F. Each 120 and 277-volt branch circuit shall have a dedicated neutral conductor. Neutral conductors shall be considered current-carrying conductors for wire derating.

2.2 REMOTE CONTROL AND SIGNAL CABLE

A. Control Cable for Class 1 Remote Control and Signal Circuits: Copper conductor, 600-volt insulation, rated 60°C, individual conductors twisted together, shielded, and covered with a PVC jacket.

B. Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, 300-volt insulation, rated 60ºC, individual conductors twisted together, shielded, and covered with a PVC jacket; UL listed.

C. Plenum Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, 300-volt insulation, rated 60°C, individual conductors twisted together, shielded, and covered with a nonmetallic jacket; UL listed for use in air handling ducts, hollow spaces used as ducts, and plenums.

2.3 FIRE-RATED CABLE AND ASSEMBLIES

A. Properties and requirements of fire rated cables and assemblies:

1. 2HR fire rated for horizontal and vertical installations.

B. Acceptable fire-rated cables and listed assemblies:

1. Feeder assembly located outside the structure (example: below finished grade) or encased in concrete; minimum 2 inches [50mm] of concrete).

2. Mineral Insulated Cables: Copper conductor, 600-volt insulation, rated 90ºC, Type MI.

PART 3 - EXECUTION

3.1 WIRE AND CABLE INSTALLATION SCHEDULE

A. Above Accessible Ceilings:

1. Building wire shall be installed in raceway.

B. All Other Locations: Building wire in raceway.

C. Above Grade: All conductors installed above grade shall be type “THHN”.

D. Underground or In Slab: All conductors shall be type “THWN”.

E. Low Voltage Cable (less than 100 volts): Low voltage cable shall be installed in raceway.

F. Fire-Rated 2-Hour Feeders and Circuit Requiring Continuous Operation (CI): Refer to Part 2 of this section for acceptable products and assemblies. Installation shall meet UL 2196.

3.2 WIRE FOR SPECIALIZED SYSTEMS

A. Wire for the following specialized systems shall be as designated on the drawings, or elsewhere in these specifications. If not designated on the drawings or specifications, the system manufacturer's recommendations shall be followed:

1. Fire alarm
2. Low voltage switching
3. Nurse call
4. Electronic control
5. Security
6. TV
7. Telephone
8. Data

3.3 CONTRACTOR CHANGES

A. The basis of design is copper conductors installed in raceway based on ambient temperature of 30°C, NEC Table 310.16. Service entrance and fire pump feeder conductors are based on copper conductor installed in underground electrical ducts, NEC Table B.310.15(B)(2)(7).

B. The Contractor shall be responsible for derating and sizing conductors and conduits to equal or exceed the ampacity of the basis of design circuits, if he/she chooses to use methods or materials other than the basis of design.

C. Underground electrical duct ampacity rating shall be in accordance with NEC Table B.310.15(B)(2)(7) or calculated in accordance with Annex B Application Information for Ampacity Calculation. The calculations and a sketch of the proposed installation shall be submitted prior to any conduit being installed.

D. Record drawing shall include the calculations and sketches.

3.4 GENERAL WIRING METHODS

A. Use no wire smaller than 12 AWG for power and lighting circuits, and no smaller than 14 AWG for control wiring.

B. Use no wire smaller than 18 AWG for low voltage control wiring (<100 volts).

C. Use 10 AWG conductor for 20 ampere, 120-volt branch circuit home runs longer than 75 feet, and for 20 ampere, 277-volt branch circuit home runs longer than 200 feet.

D. Use no wire smaller than 8 AWG for outdoor lighting circuits.

E. The ampacity of multiple conductors in one conduit shall be derated per NEC 310. In no case shall more than 4 conductors be installed in one conduit to such loads as motors larger than 1/4 HP, panelboards, motor control centers, etc.

F. Where installing parallel feeders, place an equal number of conductors for each phase of a circuit in same raceway or cable.

G. Splice only in junction or outlet boxes.

H. Neatly train and lace wiring inside boxes, equipment, and panelboards.

I. Make conductor lengths for parallel circuits equal.

J. All conductors shall be continuous in conduit from last outlet to their termination.

K. Terminate all spare conductors on terminal blocks, and label the spare conductors.

L. Cables or wires shall not be laid out on the ground before pulling.

M. Cables or wires shall not be dragged over earth or paving.

N. Care shall be taken so as not to subject the cable or wire to high mechanical stresses that would cause damage to the wire and cable.

O. At least six (6)-inch loops or ends shall be left at each outlet for installation connection of luminaires or other devices.

P. All wires in outlet boxes not connected to fixtures or other devices shall be rolled up, spliced if continuity of circuit is required, and insulated.

3.5 WIRING INSTALLATION IN RACEWAYS

A. Pull all conductors into a raceway at the same time. Use UL listed wire pulling lubricant for pulling 4 AWG and larger wires.

B. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

C. Pulling shall be continuous without unnecessary stops and starts with wire or cable only partially through raceway.

D. Where reels of cable or wire are used, they shall be set up on jacks close to the point where the wire or cable enters the conduit or duct so that the cable or wire may be unreeled and run into the conduit or duct with a minimum of change in the direction of the bend.

E. Conductors shall not be pulled through conduits until plastering or masonry work is completed and conduits are free from moisture. Care shall be taken so that long pulls of wire or pulls around several bends are not made where the wire may be permanently stretched and the insulation damaged.

F. Only nylon rope shall be permitted to pull cables into conduit and ducts.

G. Completely and thoroughly swab raceway system before installing conductors.

H. Conductor Supports in Vertical Raceways:

1. Support conductors in vertical raceways in accordance with NEC 300.19 and Table 300.19(A) Spacing of Conductors Supports.

2. Supports shall be of insulated wedge type (OZ Gedney Type S, or equal) and installed in a tapered insulated bushing fitting or a metal woven mesh with a support ring that fits inside conduit fitting installed in an accessible junction box (Hubbell Kellems support grip or equal).

3.6 CABLE INSTALLATION

A. Provide protection for exposed cables where subject to damage.

B. Use suitable cable fittings and connectors.

C. Run all open cable parallel or perpendicular to walls, ceilings, and exposed structural members. Follow the routing as illustrated on the drawings as closely as possible. Cable routing on drawings scaled 1/4”=1’-0” or less shall be considered diagrammatical, unless noted otherwise. The correct routing, when shown diagrammatically, shall be chosen by the Contractor based on information in the contract documents; in accordance with the manufacturer’s written instructions, applicable codes, the NECA’s “Standard of Installation”, recognized industry standards; and coordinated with other contractors.

D. Open cable shall be supported by the appropriate size J-hooks or other means if called for on the drawings. Wire and cable from different systems shall not be installed in the same J-hook. J-hooks shall be sized with 20% spare capacity. J-hooks shall provide proper bend radius support for data cable and fiber cables.

E. Open cable installed above suspended ceilings shall not rest on the suspended ceiling construction, nor utilize the ceiling support system for wire and cable support.

F. J-hook supports shall be installed at a maximum of five-foot (5') intervals. All J-hooks shall be installed where completely accessible and not blocked by piping, ductwork, inaccessible ceilings, etc. J-hooks shall be independently rigidly attached to a structural element. J-hooks shall be installed to provide 2” horizontal separation and 6” vertical separation between systems.

G. Open cable shall only be installed where specifically shown on the drawings, or permitted in these specifications.

3.7 FIRE-RATED CABLE AND ASSEMBLY INSTRUCTIONS

A. Terminations of the fire-rated cable must be outside of the fire zone.

B. Fire-rated cable shall be installed according to the manufacturer’s instructions, recommendations, and UL listing.

C. Route fire-rated cable and assemblies separate from other feeders and distribution. Install cable and assemblies in locations protected from physical damage.

D. Refer to Electrical Identification Section 26 05 53 for specific identification requirements.

3.8 WIRING CONNECTIONS AND TERMINATIONS

A. Splice and tap only in accessible junction boxes.

B. Use solderless, tin-plated copper, compression terminals (lugs) applied with circumferential crimp for conductor terminations, 8 AWG and larger.

C. Use solderless, tin-plated, compression terminals (lugs) applied with indenter crimp for copper conductor terminations, 10 AWG and smaller.

D. Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and smaller. For 10 AWG and smaller, use insulated spring wire connectors with plastic caps.

E. Use compression connectors applied with circumferential crimp for conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of conductor. Cold shrink connector insulator with 1kV rating shall be used in damp and wet locations.

F. Thoroughly clean wires before installing lugs and connectors.

G. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

H. Phase Sequence: All apparatus shall be connected to operate in the phase sequence A-B-C representing the time sequence in which the phase conductors so identified reach positive maximum voltage.

I. As a general rule, applicable to switches, circuit breakers, starters, panelboards, switchgear and the like, the connections to phase conductors are intended thus:

1. Facing the <u>front and operating</u> side of the equipment, the phase identification shall be:

a. Left to Right - A-B-C
b. Top to Bottom - A-B-C

J. Connection revisions as required to achieve correct rotation of motors shall be made at the load terminals of the starters or disconnect switches.

3.9 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Division 1.

B. Building Wire and Power Cable Testing: Perform an insulation-resistance test on each conductor with respect to ground and adjacent conductors. Test shall be made by means of a low-resistance ohmmeter, such as a “Megger”. The applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. The test duration shall be one minute. Insulation resistance must be greater than 100 mega-ohm for 600 volt and 25 mega-ohm for 300 volt rated cables per NETA Acceptance Testing Standard. Verify uniform resistance of parallel conductors.

C. MI cable shall have the insulation resistance of each cable tested with a 500-volt dc megohmeter prior to energizing the cables. Tabulate resistance values and submit to Architect/Engineer for acceptance.

D. Inspect wire and cable for physical damage and proper connection.

E. Torque test conductor connections and terminations to manufacturer's recommended values.

F. Perform continuity test on all power and equipment branch circuit conductors. Verify proper phasing connections.

G. Protection of wire and cable from foreign materials:

1. It is the Contractor’s responsibility to provide adequate physical protection to prevent foreign material application or contact with any wire or cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer’s performance warranty. This includes, but is not limited to, overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid, or compound that could come in contact with the cable, cable jacket, or cable termination components.

H. Overspray of paint on any wire or cable will not be accepted. It shall be the Contractor’s responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed.

END OF SECTION

SECTION 26 05 17

ELECTRIC HEAT TRACE AND SNOW MELT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Heat tracing cables
B. Snow and ice melting cables
C. Controls

1.2 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code

B. ASTM 2633 - Standard Test Method for Thermoplastic Insulations

C. ASTM B193 - Standard Test Method for Resistivity of Electrical Conductor Materials

D. UL 746B - Polymeric Materials - Long Term Property Evaluations

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 26 05 00.

B. Product Data: For each type of product indicated.

1. Field Test Reports: Submit written test reports to include test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

C. Submit manufacturer's instructions under provisions of Section 26 05 00.

1.4 COORDINATION

A. Coordinate layout and installation of electrical heating cables and system components with General Contractor.

B. Coordinate installation of snow-melting cable with installation of concrete framework and concrete placement.

1.5 WARRANTY

A. Provide a ten (10) year warranty under provisions of Section 26 05 00.

PART 2 - PRODUCTS

2.1 HEAT-TRACING CABLE

A. Self-Regulating Heating Cable:

1. Cable shall be capable of crossing over itself without overheating.

2. Provide power connection, end seal and splices as required.

3. Each circuit shall be protected by a 30-mA ground-fault protection device. Provide number of breakers based on manufacturer’s maximum length for startup at 0°F. Identify breaker in panel directory as “HEAT TAPE”.

4. Heat tape shall be meggered prior to insulating piping.

5. **[HT-1]**: Suitable for freeze protection of above grade insulated metal or plastic piping, valves, and equipment to maintain fluid temperature above 40°F. 8 watts per foot @ 50°F, 277V.

   a. Approved Manufacturers: Ray-Chem XL1, Chromalox SRL, Thermon BSX.

6. **[HT-2]**: Suitable for freeze protection of underground insulated metal or plastic piping to maintain fluid temperature above 40°F. 8 watts per foot, 277 V.

   a. Approved Manufacturers: Ray-Chem XL, Chromalox SRL, Thermon BSX.

2.2 CONTROLS

A. Ambient Thermostat:

1. Remote bulb unit with adjustable temperature range from 15°F to 150°F (-9°C to 60°C) snap action, open-on-rise, single-pole double throw switch with 22A 125/250/480VAC ratings. Provide one pipe thermostat for each circuit of heat trace.

2. Acceptable Manufacturer: Pentair AMC-1A.

B. Pipe Thermostat:

1. Ambient sensing unit with adjustable temperature range from 15°F to 150°F (-9°C to 60°C) snap action; open-on-rise, single-pole double throw switch with 22A 125/250/480VAC ratings; and remote bulb for directly sensing pipe-wall temperature. Provide one pipe thermostat for each circuit of heat trace.

2. Acceptable Manufacturer: Pentair AMC-1A.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surface and substrates to receive heating cables for compliance with requirements for installation, tolerances, and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electrical heating cables are free of burrs and sharp protrusions.

2. Ensure pipe testing is complete.

3. Ensure surfaces and substrates are level and plumb.

B. Test cables for electrical continuity before installing.

C. Test cables for insulation resistance before installing.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

E. Verify field measurements are as shown on the Drawings.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. The heating cable shall be protected from where it leaves the pavement to the junction box by installing the cable in rigid metal conduit. Use one conduit for each heating cable.

C. Avoid crossing expansion, construction, or control joints with heating cables. Provide sufficient slack conductor in expansion loop.

D. Do not energize cables embedded in concrete, asphalt, or plaster until those assemblies are cured, except for brief testing.

E. Install cables after applying bituminous binder course to lower base. Ensure that second labeling bituminous binder is applied to cables before pouring finish topping.

F. Provide labeling in paving where snow melt cables are present. A metal plate or stamp used prior to concrete setting must contain the name of the snow melt company, the word "CAUTION", the phrase "EMBEDDED SNOW MELTING SYSTEM", and the date the system was installed. The labeling of the system must be able to handle the outdoor environment without degrading.

G. Provide labeling to outside of the pipe thermal insulation weather barrier to indicate the presence of electric heating tracing. Labeling should contain the name of the heat trace company, the word "CAUTION" and the phrase 'ELECTRIC HEAT TRACE". Labels should be placed every ten feet of pipe alternating on either side of the pipe.

3.3 CONNECTIONS

A. Cable splices and repairs shall be made using a splice kit provided by the manufacturer and specifically designed for that purpose.

B. Power connection and end seal junction box shall be mounted above grade. The junction box shall be installed in such a way so that water cannot enter it.

3.4 FIELD QUALITY CONTROL

A. Inspect cable for physical damage before installation.

B. Test cables for electrical continuity before energizing.

C. Test cables for insulation resistance before energizing. Remove cables if measured resistance is less than 10 megohms to ground.

D. Repeat test for continuity and insulation resistance after applying paving or thermal insulation.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Equipment grounding system
B. Bonding system
C. Grounding electrode system

1.2 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the International Electrical Testing Association and that is acceptable to authorities having jurisdiction.

B. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association to supervise on-site testing specified in Part 3.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with UL 467 Grounding and Bonding Equipment.

E. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

F. Comply with NFPA 70; for overhead-line construction and medium-voltage underground construction, comply with IEEE/ANSI C2 National Electrical Safety Code (NESC).

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 26 05 00.

B. Field Test Reports: Submit written test reports to include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

C. Indicate layout of ground field, location of system grounding electrode connections, and routing of grounding electrode conductor and ground ring.

1.4 SUMMARY

A. This section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

PART 2 - PRODUCTS

2.1 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 26 Section 26 05 13 "Wire and Cable".

B. Material: Copper.

C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Grounding Electrode Conductors: Stranded cable.

E. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.

F. Sizes and types below are typical. Adjust to suit Project conditions and requirements.

G. Copper Bonding Conductors: As follows:

1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch in diameter.

2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.

3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

H. **[GB]:** Grounding Bus:

1. Bare, annealed copper bars of rectangular cross section, with insulators. 1/4” x 2” x 24”.

I. **[IBT]:** Intersystem Bonding Termination:

1. Copper bar, 1/4” x 2” x 24”. Provide with wall mounting brackets, insulators and pre-tapped holes.

2. Approved Manufacturers: Harger GBI Series, Erico B544 Series.

2.2 CONNECTOR PRODUCTS

A. Comply with UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Connectors: Hydraulic compression type or exothermic-welded type, in kit form, and selected per manufacturer’s written instructions.

C. Bolted Connectors: Bolted-pressure-type connectors.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel.

B. Ground Rods: Sectional type; copper-clad steel.

1. Size: 3/4" in diameter by 120 inches per section.

C. Chemical Electrodes: Copper tube, straight or L-shaped, filled with nonhazardous chemical salts, terminated with a 4/0 bare conductor. Provide backfill material recommended by manufacturer.

D. Concrete-Encased Grounding Electrode (Ufer): Fabricate according to NFPA 70, Paragraph 52-(3), using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG or 20 feet (6.0 m) of 1/2” (13mm) steel reinforcing bar.

2.4 STATIC DISCHARGE REEL

A. **[DR-1]:** Heavy-Duty Enclosed Discharge Reel:

1. Heavy-duty discharge reel with steel enclosed housing, ratchet lock with on/off switch, 50’ nylon covered stainless steel cable with hand clamp.

2. Approved Manufacturers: Gleason Reel Corp SD-2050OS

PART 3 - EXECUTION

3.1 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.

2. Make connections with clean, bare metal at points of contact.

3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.

4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.

5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

D. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

E. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

F. Structural Steel Connection: Exothermic-welded connections to structural steel. Coordinate with structure to provide physical protection.

G. Connections at Test Wells: Use compression-type connectors on conductors and make two bolted- and clamped-type connections between conductors and ground rods.

H. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

I. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.2 INSTALLATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Each grounding conductor that passes through a below grade wall must be provided with a waterstop.

C. Grounding electrode conductor (GEC) shall be protected from physical damage by rigid polyvinyl chloride conduit (PVC) in exposed locations.

D. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then use a bolted clamp. Bond straps directly to the basic structure, taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

E. In raceways, use insulated equipment grounding conductors.

F. Underground Grounding Conductors: Use tinned copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches below grade or bury 12 inches above duct bank when installed as part of the duct bank.

3.3 EQUIPMENT GROUNDING SYSTEM

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in all feeders and circuits. Terminate each end on a grounding lug or bus.

C. Busway Supply Circuits: Install insulated equipment grounding conductor from the grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

D. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-circuit runs from computer-area power panels or power-distribution units.

E. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

F. Isolated Grounding Circuits: Install an insulated equipment grounding conductor connected to the receptacle or equipment grounding terminal. Isolate grounding conductor from raceway and from panelboard grounding terminals. Terminate at isolated equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

G. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.

3.4 BONDING SYSTEM

A. At building expansion joints, provide flexible bonding jumpers to connect to columns or beams on each side of the expansion joint.

B. Isolated Equipment Enclosure: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate equipment bonding conductor.

C. Exterior Metallic Pull and Junction Box Covers, Metallic Hand Rails: Bond to grounding system using flexible grounding conductors.

D. Equipment Circuits: Install a bonding conductor to equipment mounted electrical devices operating at 120 V and more, including air cleaners, dampers, and heaters. Bond conductor to each unit and to air duct. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps or copper conductor sized equal to the equipment grounding conductor.

E. Bond metal ducts of dust collectors, particulate conveying, fume hoods, and other hazardous materials to the equipment grounding conductors of associated pumps, fans, or blowers. Use braided-type bonding straps. Provide braided bare copper bonding conductor in nonmetallic dust collector ductwork to each equipment inlet location, and bond to equipment.

F. Water Heater, Heat-Tracing, Metal Well Casing, and Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and anti-frost heating cable. Bond conductor to heater units, piping, well casing, connected equipment, and components.

G. Connect bonding conductors to metal water pipe using a suitable ground clamp. Make connections to flanged piping at street side of flange. Provide bonding jumper around water meter.

H. Connect bonding conductors to all metal gas piping on site using a suitable ground clamp.

I. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 6 AWG minimum insulated bonding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location. Leave 10 feet of slack conductor at terminal board.

J. Telecom Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bar.

K. Terminal Cabinets: Terminate bonding conductor on cabinet grounding terminal.

L. Remote control, signaling, and fire alarm circuits shall be bonded in accordance with the most recent version of the National Electric Code.

M. Metal Poles Supporting Outdoor Lighting Fixtures > 15 feet: Provide a grounding electrode in addition to installing a separate equipment grounding conductor with supply branch-circuit conductors.

3.5 GROUNDING ELECTRODE SYSTEM

A. Ground Ring (Counterpoise):

1. Ground the steel framework of the building/equipment with a driven ground rod at the base of every corner, column, and at intermediate locations at average distances not more than 20 feet (18 m) apart. Provide a grounding conductor, electrically connected to each ground rod and to each steel column or equipment frame, extending around the perimeter of the building/equipment. Use tinned-copper conductor not less than No. 2 AWG for ground ring and for tap to building/equipment steel. Bury conductor not less than 30 inches (760 mm) below grade, 24 inches (600 mm) from building foundation, and 18 inches (459 mm) outside of roof drip line.

B. Supplementary Grounding Electrode: Use driven ground rod on exterior of building.

C. Provide bonding at Utility Company's metering equipment and pad mounted transformer.

D. Ground Rods: Install at least two rods spaced at least 20 feet from each other and located at least the same distance from other grounding electrodes.

1. Drive ground rods until tops are 12 inches below finished floor or final grade, unless otherwise indicated.

2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.

E. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

F. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.

G. Bond each aboveground portion of natural gas metallic piping system at equipment locations. The equipment grounding conductor may serve as the bonding means.

H. Concrete-Encased Grounding Electrode (Ufer): Install concrete-encased grounding electrode encased in at least 2 inches (50mm) of concrete horizontally within the foundation that is in contact with the earth. If concrete foundation is less than 20 feet long, coil excess conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to a grounding electrode external to concrete.

3.6 CONCRETE OR WOOD BUILDING GROUNDING SYSTEM

A. Provide a copper common grounding electrode conductor for the attachment of multiple separately derived systems in accordance with NEC 250.30(A)(4)(a) through 250.30(A)(4)(c). Individual grounding conductor taps from the separately derived systems to the common grounding electrode shall be sized in accordance with NEC 250.66. All tap connections shall be made in an accessible location in such a manner that common grounding electrode conductor remains without a splice or joint.

3.7 EQUIPOTENTIAL (MULTI-POINT) GROUNDING SYSTEM

A. Provide an equipotential grounding system in the following locations:

1. Critical patient care and special care areas as indicated on drawings.

B. The non-current-carrying metal parts of equipment, raceways and other enclosures shall be bonded to the grounding system.

3.8 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

1. Measure ground resistance from system neutral connection at service entrance to convenient ground reference points using suitable ground testing equipment. Resistance shall not exceed 5 ohms.

2. Testing: Owner will engage a qualified testing agency to perform the following field quality-control testing:

3. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

4. Testing: Perform the following field quality-control testing:

   a. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.

   b. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.

   c. Provide drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

      1) Equipment Rated 500 kVA and Less: 10 ohms.
      2) Equipment Rated 500 to 1000 kVA: 5 ohms.
      3) Equipment Rated More Than 1000 kVA: 3 ohms.
      4) Substations and Pad-Mounted Switching Equipment: 5 ohms.
      5) Manhole Grounds: 10 ohms.

   d. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect/Engineer promptly and include recommendations to reduce ground resistance.

3.9 GRADING AND PLANTING

A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Comply with Division 2. Maintain restored surfaces. Restore disturbed paving.

END OF SECTION

SECTION 26 05 27

SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Conduit and equipment supports
B. Fastening hardware
C. Concrete housekeeping pads

1.2 QUALITY ASSURANCE

A. Support systems shall be adequate for weight of equipment and conduit, including wiring, which they carry.

1.3 COORDINATION

A. Coordinate size, shape and location of concrete pads with Section on Cast-in-Place Concrete or Concrete Topping.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Allied Support Systems
B. Cooper B-Line
C. Erico, Inc.
D. Hilti
E. Power Fasteners

2.2 MATERIAL

A. Support Channel: Stainless steel for wet/damp locations; painted steel for interior/dry locations. All field cut ends shall be touched up with matching finish to inhibit rusting.

B. Hardware: Corrosion resistant.

C. Anchorage and Structural Attachment Components:

1. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to Authorities Having Jurisdiction.

    a. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

2. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.

3. Welding Lugs: Comply with MSS-SP-69, Type 57.

4. Beam clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

5. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

6. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

7. <u>Concrete Anchors</u>: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-08. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.

8. <u>Masonry Anchors:</u> Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

D. Conduit Sleeves and Lintels:

1. Each Contractor shall provide, to the General Contractor for installation, lintels for all openings required for the Contractor’s work in masonry walls and conduit sleeves for floors, unless specifically shown as being by others.

2. Refer to Structural General Notes for lintel requirements in masonry construction.

3. Fabricate all lintels from structural steel shapes or as indicated on the drawings. All lintels and grouped wall openings shall be approved by the Architect or Structural Engineer.

4. Fabricate all sleeves from standard weight black steel pipe. Provide continuous sleeve. Cut or split sleeves are not acceptable. Sleeves through concrete walls may be high density polyethylene pipe penetration sleeve with a water stop collar, suitable for use with Link-Seal mechanical seals. Century-Line Model CS.

5. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.

6. Sleeves shall not penetrate structural members without approval from the Structural Engineer.

7. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.

8. Install all sleeves concentric with conduits. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.

9. Where conduits rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (asphalt and cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

10. Size sleeves large enough to allow expansion and contraction movement.

E. Concrete Housekeeping Pads:

1. Concrete bases for all floor mounted equipment and wall mounted equipment which is surface mounted and extends to within 6" of the finished floor, unless shown otherwise on the drawings, shall be 3-1/2" thick concrete.

2. Bases shall extend 3" on all sides of the equipment (6" larger than factory base).

3. Where the base is less than 12" from a wall, the base shall be carried to the wall to prevent a "dirt-trap".

4. Concrete materials and workmanship required for the Contractor's work shall be provided by him. Materials and workmanship shall conform to the applicable standards of the Portland Cement Association. Reinforce with 6” x 6”, W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at twenty-eight days.

F. Rooftop Support System:

1. Provide pre-fabricated roof supports for all conduit and equipment installed above the roof. Support all conduit and equipment a minimum of 4” above roof.

2. Support system shall be compatible with single ply, bituminous, metal, and spray foam roof systems. The base shall be rounded to prevent damage to the roof, and drainage holes shall prevent ponding of water in the support.

3. All metal components shall be hot dipped galvanized. Mounting hardware shall be stainless steel or hot dipped galvanized. Support shall be UV, corrosion, and freeze/thaw resistant. Support shall include orange paint, reflective safety orange accents, or similar markings for increased visibility.

4. Acceptable Products: Anvil International HBS-Base Series, Cooper B-Line Dura-Blok, Erico Caddy Pyramid 50, 150, 300, or 600 (to match load).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using expansion anchors in concrete and beam clamps on structural steel.

B. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchor on concrete surfaces; sheet metal screws in sheet metal studs; and wood screws in wood construction.

C. Do not fasten supports to ceiling systems, piping, ductwork, mechanical equipment, or conduit, unless otherwise noted.

D. Do not use powder-actuated anchors without specific permission.

E. Do not drill structural steel members.

F. Fabricate supports from structural steel or steel channel, rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring lock washers under all nuts.

G. In wet locations and on all building floors below exterior earth grade install free-standing electrical equipment on concrete pads.

H. Install cabinets and panelboards with minimum of four anchors. Provide horizontal backing/support framing in stud walls for rigid mounting.

I. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.

J. Do not exceed 25 lbs. per hanger and a minimum spacing of 2’-0” on center when attaching to metal roof decking (excludes concrete on metal deck). This 25 lbs. load and 2’-0” spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

K. Refer to Section 26 05 33 for special conduit supporting requirements.

3.2 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.

B. Trim all ends of exposed field fabricated steel hangers, slotted channel and threaded rod to within 1” of support or fastener to eliminate potential injury to personnel unless shown otherwise on the drawings. Smooth ends and install elastomeric insulation with two coats of latex paint if exposed steel is within 6’-6” of finish floor and presents potential injury to personnel.

END OF SECTION

SECTION 26 05 33

CONDUIT AND BOXES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Rigid metallic conduit and fittings (RMC)
B. Intermediate metallic conduit and fittings (IMC)
C. Electrical metallic tubing and fittings (EMT)
D. Flexible metallic conduit and fittings (FMC)
E. Liquidtight flexible metallic conduit and fittings (LFMC)
F. Rigid polyvinyl chloride conduit and fittings (PVC)
G. High density polyethylene conduit and fittings (HDPE)
H. Wall and ceiling outlet boxes
I. Electrical connection
J. Pull and junction boxes
K. Rough-ins
L. Handholes
M. Accessories

1.2 RELATED WORK

A. Section 26 05 53 – Electrical Identification: Refer to electrical identification for color and identification labeling requirements.

1.3 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C80.1 - Rigid Steel Conduit, Zinc-Coated
2. ANSI C80.3 - Electrical Metallic Tubing, Zinc-Coated and Fittings
3. ANSI C80.4 - Fittings for Rigid Metal Conduit and Electrical Metallic Tubing
4. ANSI C80.6 – Intermediate Metal Conduit, Zinc Coated
5. ANSI/NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports
6. ANSI/NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports

B. Federal Specifications (FS):

1. A–A–50553A – Fittings for Conduit, Metal, Rigid, (Thick-Wall and Thin-Wall (EMT) Type
2. A–A–55810 – Specification for Flexible Metal Conduit

C. NECA “Standards of Installation”

D. National Electrical Manufacturers Association (NEMA):

1. ANSI/NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable

2. RN 1 – Polyvinyl chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
3. TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit
4. TC 9 – Fittings for PVC Plastic Utilities Duct for Underground Installation

E. NFPA 70 – National Electrical Code (NEC)

F. Underwriters Laboratories (UL): Applicable Listings

1. UL 1 – Flexible Metal Conduit
2. UL 6 – Rigid Metal Conduit
3. UL 360 – Liquid Tight Flexible Steel Conduit
4. UL514-B – Conduit Tubing and Cable Fittings
5. UL651-A – Type EB and a PVC Conduit and HDPE Conduit
6. UL651-B – Continuous Length HDPE Conduit
7. UL746A – Standard for Polymeric Materials – Short Term Property Evaluations
8. UL797 – Electrical Metal Tubing
9. UL1242 – Intermediate Metal Conduit

G. American Standard of Testing and Materials (ASTM):

1. ASTM D 570 - Standard Test Method for Water Absorption of Plastics
2. ASTM D 638 - Standard Test Method for Tensile Properties of Plastics
3. ASTM D 648 - Standard Test Method for Deflection Temperature of Plastics under Flexural Load in the Edge Wise Position
4. ASTM D 2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
5. ASTM D 2447 - Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter
6. ASTM D 3350 - Standard Specification for Polyethylene Plastic Pipe and Fittings Material

H. Definitions:

1. Fittings: Conduit connection or coupling.

2. Body: Enlarged fittings with opening allowing access to the conductors for pulling purposes only.

3. Mechanical Spaces: Enclosed areas, usually kept separated from the general public, where the primary use is to house service equipment and to route services. These spaces generally have exposed structures, bare concrete and non-architecturally emphasized finishes.

4. Finished Spaces: Enclosed areas where the primary use is to house personnel and the general public. These spaces generally have architecturally emphasized finishes, ceilings and/or floors.

5. Concealed: Not visible by the general public. Often indicates a location either above the ceiling, in the walls, in or beneath the floor slab, in column coverings, or in the ceiling construction.

6. Above Grade: Not directly in contact with the earth. For example, an <u>interior</u> wall located at an elevation below the finished grade shall be considered above grade but a wall retaining earth shall be considered below grade.

7. Slab: Horizontal pour of concrete used for a floor or sub-floor.

PART 2 - PRODUCTS

2.1 RIGID METALLIC CONDUIT (RMC) AND FITTINGS

A. Acceptable Manufacturers:

1. Acceptable Manufacturers: Allied, LTV, Steelduct, Wheatland Tube Co, O-Z Gedney, or approved equal.

2. Acceptable Manufacturers of RMC Conduit Fittings: Appleton Electric, O-Z/Gedney Co., Electroline, Raco, Bridgeport, Midwest, Regal, Thomas & Betts, Crouse-Hinds, Killark, or approved equal.

B. Minimum Size Galvanized Steel: 3/4 inch (19mm), unless otherwise noted.

C. Fittings and Conduit Bodies:

1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.

2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.

3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.

4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. **High impact phenolic threaded type bushings are not acceptable.**

5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

D. PVC Externally Coated Conduit: Compliant with UL 6, ANSI C80.1 and NEMA RN 1; rigid galvanized steel conduit with external 40 mil PVC coating and internal 2 mil urethane coating surface. All fittings and conduit bodies shall be complete with coating. Threads shall be hot galvanized and coated with a clear coat of urethane. The PVC coated system shall include necessary PVC coated fittings, boxes and covers to form a complete encapsulated system. Acceptable Manufacturers: Robroy, T&B Ocal or approved equal.

2.2 STAINLESS STEEL CONDUIT (316SS) AND FITTINGS

A. Acceptable Manufacturers: Gibson Stainless & Specialty, Calbrite, Eaton/Crouse-Hinds, Thomas & Betts, or approved equal.

B. All material shall be Type 316 stainless steel, meet ASTM A-321 and SA-312 standards, and be UL 6A approved.

C. All conduit shall be heavy wall Schedule 40 with standard NPT threads.

D. Minimum Size Stainless Steel: 3/4 inch (19mm), unless otherwise noted.

E. Fittings, conduit bodies, couplings, nipples, bushings, connectors, supports, clamps, and all accessory hardware shall be made of Type 316 stainless steel.

2.3 INTERMEDIATE METALLIC CONDUIT (IMC) AND FITTINGS

A. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers: Allied, LTV, Steelduct, Wheatland Tube Co, O-Z Gedney, or approved equal.

C. Fittings and Conduit Bodies:

1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.

2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.

3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.

4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. **High impact phenolic threaded type bushings are not acceptable.**

5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

2.4 ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS

A. Minimum Size Electrical Metallic Tubing: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers of EMT Conduit: Allied, LTV, Steelduct, Wheatland Tube Co, or approved equal.

C. Fittings and Conduit Bodies:

1. 2" Diameter or Smaller: Compression type of steel designed for their specific application.

2. Larger than 2": Compression type of steel designed for their specific application.

3. Acceptable Manufacturers of EMT Conduit Fittings: Appleton Electric, O-Z/Gedney Co., Electroline, Raco, Bridgeport, Midwest, Regal, Thomas & Betts, or approved equal.

2.5 FLEXIBLE METALLIC CONDUIT (FMC) AND FITTINGS

A. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted. Lighting branch circuit wiring to an individual luminaire may be a manufactured, UL listed 3/8” flexible metal conduit and fittings with #14 AWG THHN conductors and an insulated ground wire. Maximum length of 3/8” FMC shall be six (6) feet.

B. Acceptable Manufacturers: American Flex, Alflex, Electri-Flex Co, or approved equal.

C. Construction: Flexible steel, approved for conduit ground, zinc coated, threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel. Provide a separate equipment grounding conductor when used for equipment where flexibility is required.

D. Fittings and Conduit Bodies:

1. Threadless hinged clamp type, galvanized zinc coated cadmium plated malleable cast iron or screw-in type, die-cast zinc.

2. Fittings and conduit bodies shall include plastic or cast metal inserts supplied by the manufacturer to protect conductors from sharp edges.

3. Acceptable Manufacturers: O-Z/Gedney Co., Thomas & Betts, Appleton Electric, Electroline, Bridgeport, Midwest, Regal, or approved equal.

2.6 LIQUIDTIGHT FLEXIBLE METALLIC CONDUIT (LFMC) AND FITTINGS

A. Acceptable Manufacturers: Anaconda Type UA, Electri-Flex Type LA, Alflex, Carlon (Lamson & Sessions), or approved equal.

B. Construction: Flexible steel, approved for conduit ground, zinc coated, threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel and an extruded PVC cover.

C. Fittings and Conduit Bodies:

1. Watertight, compression type, galvanized zinc coated cadmium plated malleable cast iron, UL listed.

2. Fittings and conduit bodies shall include plastic or cast metal inserts supplied by the manufacturer to protect conductors from sharp edges.

3. Acceptable Manufacturers: Appleton Electric, O-Z/Gedney Co., Electroline, Bridgeport, Thomas & Betts, Midwest, Regal, Carlon (Lamson & Sessions), or approved equal.

2.7 RIGID NON-METALLIC CONDUIT (PVC) AND FITTINGS

A. Minimum Size Rigid Smooth-Wall Nonmetallic Conduit: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers: Carlon (Lamson & Sessions) Type 40, Cantex, J.M. Mfg., or approved equal.

C. Construction: Schedule 40 and Schedule 80 rigid polyvinyl chloride (PVC), UL labeled for 90°C.

D. Fittings and Conduit Bodies: NEMA TC 3; sleeve type suitable for and manufactured especially for use with the conduit by the conduit manufacturer.

E. Plastic cement for joining conduit and fittings shall be provided as recommended by the manufacturer.

2.8 HIGH DENSITY POLYETHYLENE (HDPE)

A. Minimum Size: 2 inch, unless noted otherwise.

B. Acceptable Manufacturers: Carlon, Chevron Phillips Chemical Company, or approved equal.

C. Materials used for the manufacture of polyethylene pipe and fittings shall be extra high molecular weight, high-density polyethylene resin. The material shall be listed by PPI (Plastic Pipe Institute) and shall meet the following resin properties:

ASTM Test	Description	Values HDPE
D-1505	Density g/CM 3	< .941
D-1238	Melt Index, g/10 min Condition E	> .55 grams/10 min.
D-638	Tensile Strength at yield (psi)	3000 min.
D-1693	Environmental Stress Crack Resistance Condition B, F 20	96 hrs.
D-790	Flexural Modulus, MPa (psi)	< 80,000
D-746	Brittleness Temperature	-75°C Max

D. The pipe shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same raw material, including both the base resin and coextruded resin. The pipe shall be homogeneous throughout and free of visible cracks, holes, voids, foreign inclusions, or other defects that may affect the wall integrity.

E. Fitting and Conduit Bodies:

1. Directional Bore and Plow Type Installation: Electrofusion or Universal Aluminum threaded couplings. Tensile strength of coupled pipe must be greater than 2,000 lbs.

2. For all other type of installation: Coupler must provide a water tight connection. The tensile strength of coupled pipe must be greater than 1,000 lbs.

3. E-loc type couplings are not acceptable in any situations.

4. Acceptable Manufacturers: ARCON, Carlon, or approved equal.

2.9 OUTLET BOXES

A. Sheet Metal Outlet Boxes: ANSI/NEMA OS 1; galvanized steel, minimum of 14 gauge, with 1/2-inch male fixture studs where required.

B. Nonmetallic Outlet Boxes: ANSI/NEMA OS 2.

C. Cast Boxes: NEMA FB1, Type FD, Aluminum or cast feralloy, deep type, gasketed cover, threaded hubs.

D. Outlet boxes for luminaires to be not less than 1-1/2" deep, deeper if required by the number of wires or construction. The box shall be coordinated with surface luminaires to conceal the box from view or provide a finished trim plate.

E. Switch outlet boxes for local light control switches, dimmers and occupancy sensors shall be 4 inches square by 2-1/8 inches deep, with raised cover to fit flush with finish wall line. Multiple gang switch outlets shall consist of the required number of gang boxes appropriate to the quantity of switches comprising the gang. Where walls are plastered, provide a plaster raised cover. Where switch outlet boxes occur in exposed concrete block walls, boxes shall be installed in the block cavity with a raised square edge tile cover of sufficient depth to extend out to face of block or masonry boxes.

F. Outlet boxes for telephone substations in walls and columns shall be 4 inches square and 2-1/8 inches deep with single gang raised cover to fit flush with finished wall line equipped with flush telephone plate.

G. Wall or column receptacle outlet boxes shall be 4 inches square with raised cover to fit flush with finished wall line. Boxes in concrete block walls shall be installed the same as for switch boxes in block walls.

2.10 [ECONN]: ELECTRICAL CONNECTION

A. Electrical connection to equipment and motors, sized per NEC. Coordinate requirements with contractor furnishing equipment or motor. Refer to specifications and general installation notes for terminations to motors.

2.11 [JB]: PULL AND JUNCTION BOXES

A. Sheet Metal Boxes: ANSI/NEMA OS 1; galvanized steel.

B. Sheet metal boxes larger than 12 inches in any dimension that contain terminations or components: Continuous hinged enclosure with 1/4 turn latch and white back panel for mounting terminal blocks and electrical components.

C. Cast Metal Boxes for Outdoor and Wet Location Installations: NEMA 250; Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as raintight. Galvanized cast iron box and cover with ground flange, neoprene gasket, and stainless steel cover screws.

D. Cast Metal Boxes for Underground Installations: NEMA 250; Type 4, inside flanged, recessed cover box for flush mounting, UL listed as raintight. Galvanized cast iron box and plain cover with neoprene gasket and stainless steel cover screws.

E. Flanged type boxes shall be used where installed flush in wall.

2.12 ROUGH-IN

A. Provide with one (1) flush mount double gang box with single gang plaster ring and appropriate cover plate,

B. Conduit stubbed to above the lay-in ceiling.

C. **[RI-TECH]**: Technology Rough-in:

1. Rough-in shall have one (1) 1” conduit.

D. **[RI-TECH-W]**: Technology Rough-in - Wall Phone:

1. Mount on wall +54” or as noted in plans. Rough-in shall have one (1) 1” conduit.

E. **[RI-TV]**: Television Antenna Outlet Box Rough-in:

1. Rough-in shall have one (1) 3/4” conduit.

2.13 HANDHOLES

A. **[HH-1]**: Handhole, composite polymer concrete body and cover. Stainless steel hardware. Bolted non-skid cover rated for 20,000 pounds. Design load occasional non-deliberate vehicular traffic. Stack units to achieve depth shown on plans. Units in landscaped areas shall be green in color. 11”W, 18”L, 18”D or dimensions as shown on plans.

1. Approved Manufacturers:

a. Hubbell/Quazite PG####BB18, PG####HA00
b. Carson Industries H Series
c. Armorcast
d. Highline Products
e. Synertech

B. **[HH-2]**: Handhole, cast iron, hot dipped galvanized with checkered cover sidewalk weatherproof box, flat neoprene cover gasket. Stainless steel screw hardware. Mounted flush in concrete. 12”W, 18”L, 12”D or dimensions as shown on plans.

1. Approved Manufacturers:

a. Appleton Electric WYT Series, WYT 181212
b. OZ Gedney YT Series
c. Crouse Hinds WJBF Series

C. **[HH-3]**: Handhole, concrete traffic box and galvanized steel checkered cover. Stainless steel hardware. Bolted cover and box rated for H/20 vehicular traffic. Reinforced concrete slab for bottom. 11”W, 18”L, 24”D or dimensions as shown on plans.

1. Approved Manufacturer: Oldcastle Precast B1017 Box

2.14 ACCESSORIES

A. Fire Rated Moldable Pads: UL #9700, moldable sheet putty at required thickness on all five sides of back boxes. Kinetics Noise Control – IsoBacker Pad, SpecSeal – SSP Putty and Pads, 3M #MPP-4S or equal.

B. Sound Barrier Insulation Pads: Mastic, non-hardening, sheet material, minimum 1/8" thickness applied to all five sides of back boxes. Kinetics Noise Control – SealTight Backer Pad, L.H. DOTTIE Co., #68 or equal.

PART 3 - EXECUTION

3.1 CONDUIT SIZING

A. Size conduit as shown on the drawings and specifications. Where not indicated in the contract documents, conduit size shall be according to NEC. Conduit and conductor sizing shall be coordinated to limit conductor fill to less than 40%, maintain conductor ampere capacity as required by the NEC (to include enlarged conductors due to temperature and quantity derating values) and to prevent excessive voltage drop and pulling tension due to long conduit/conductor lengths.

B. <u>Minimum</u> Conduit Size (Unless Noted Otherwise):

1. Above Grade: 3/4 inch. (The use of 1/2 inch would be allowed for installation conduit to individual light switches, individual receptacles and individual fixture whips from junction box.)

2. Below Grade 5' or less from Building Foundation: 1 inch.

3. Below Grade More than 5' from Building Foundation: 1 inch.

4. Telecommunication Conduit: 1 inch.

5. Controls Conduit: 3/4 inch.

C. Conduit sizes shall change only at the entrance or exit to a junction box, unless specifically noted on the drawings.

3.2 CONDUIT ARRANGEMENT

A. In general, conduit shall be installed concealed in walls, in finished spaces and where possible or practical, or as noted otherwise. Conduit shall be installed parallel or perpendicular to walls, ceilings, and exposed structural members. In unfinished spaces, mechanical and utility areas, conduit may run either concealed or exposed as conditions dictate and as practical unless noted otherwise on drawings. Installation shall maintain headroom in exposed vicinities of pedestrian or vehicular traffic.

B. Exposed conduit on exterior walls or above roof will not be allowed without prior written approval of Architect/Engineer. A drawing of the proposed routing and a photo of the location shall be submitted 14 days prior to start of conduit rough-in. Routing shall be shown on coordination drawings.

C. Conduit shall not share the same cell as structural reinforcement in masonry walls.

D. Conduit runs shall be routed as shown on large scale drawings. Conduit routing on drawings scaled 1/4"=1'-0" or less shall be considered diagrammatic, unless noted otherwise. The correct routing, when shown diagrammatically shall be chosen by the Contractor based on information in the contract documents, in accordance with manufacturer's written instructions, applicable codes, the NECA's "Standard of Installation", in accordance with recognized industry standards, and coordinated with other contractors.

E. Contractor shall adapt his work to the job conditions and make such changes as required and permitted by the Architect/Engineer, such as moving to clear beams and joists, adjusting at columns, avoiding interference with windows, etc., to permit the proper installation of other mechanical and/or electrical equipment.

F. Contractor shall cooperate with all Contractors on the project. He shall obtain details of other Contractor's work to ensure fit and avoid conflict. Any expense due to the failure of This Contractor to do so shall be paid for in full by him. The other trades involved as directed by the Architect/Engineer shall perform the repair of work damaged as a result of neglect or error by This Contractor. The resultant costs shall be borne by This Contractor.

3.3 CONDUIT SUPPORT

A. Conduit runs installed above a suspended ceiling shall be properly supported. In no case shall conduit rest on the suspended ceiling construction, nor utilize ceiling support system for conduit support.

B. Conduit shall <u>not</u> be supported from ductwork, water, sprinkler piping, or other non-structural members, unless approved by the Architect/Engineer. All supports shall be from structural slabs, walls, structural members, and bar joists, and coordinated with all other applicable contractors, unless noted otherwise.

C. Conduit shall be held in place by the correct size of galvanized one-hole conduit clamps, two-hole conduit straps, patented support devices, clamp back conduit hangers, or by other means if called for on the drawings.

D. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

E. Spring-steel conduit clips specifically designed for supporting single conduits or tubing may be used in lieu of malleable-iron hangers for 1" and smaller raceways serving lighting and receptacle branch circuits above accessible ceilings and for securing raceways to slotted channel and angle supports.

F. Group conduits in parallel runs where practical and use conduit racks or trapeze hangers constructed of steel channel, suspended with threaded solid rods or wall mounted from metal channels with conduit straps or clamps. Provide space in each rack or trapeze for 25% additional conduits.

G. Do not exceed 25 lbs. per hanger and a minimum spacing of 2’-0” on center when attaching to metal roof decking (excludes concrete on metal deck). This 25 lbs. load and 2’-0” spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

I. Supports for metallic conduit shall be no greater than 10 feet. A smaller interval may be used if necessitated by building construction, but in no event shall support spans exceed the NEC requirements. Conduit shall be securely fastened within 3 feet of each outlet box, junction box, device box, cabinet, or fitting.

J. Supports of flexible conduit shall be within 12 inches of each outlet box, junction box, device box, cabinet, or fitting and at intervals not to exceed 4.5 feet.

K. Supports for non-metallic conduit shall be at sufficiently close intervals to eliminate any sag in the conduit. The manufacturer's recommendations shall be followed, but in no event shall support spans exceed the NEC requirements.

L. Where conduit is to be installed in poured concrete floors or walls, provide concrete-tight conduit inserts securely fastened to forms to prevent conduit misplacement.

M. Finish:

1. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.

2. Trim all ends of exposed field fabricated steel hangers, slotted channel and threaded rod to within 1” of support or fastener to eliminate potential injury to personnel unless shown otherwise on the drawings. Smooth ends and install elastomeric insulation with two coats of latex paint if exposed steel is within 6’-6” of finish floor and presents potential injury to personnel.

3.4 CONDUIT INSTALLATION

A. Conduit Connections:

1. Shorter than standard conduit lengths shall be cut square using industry standards. The ends of all conduits cut shall be reamed or otherwise finished to remove all rough edges.

2. Metallic conduit connections in slab on grade installation shall be sealed and one coat of rust inhibitor primer applied after the connection is made.

3. Where conduits with tapered threads cannot be coupled with standard couplings, then approved split or Erickson couplings shall be used. Running threads will <u>not</u> be permitted.

4. Install expansion/deflection joints where conduit crosses structure expansion/seismic joints.

B. Conduit terminations for all low voltage wiring shall have nylon bushings installed on each end of every conduit run.

C. Conduit Bends:

1. Use a hydraulic one-shot conduit bender or factory elbows for bends in conduit 2" in size or larger. All steel conduit bending shall be done cold; no heating of steel conduit shall be permitted.

2. All bends of rigid polyvinyl chloride conduit (PVC) shall be made with the manufacturer's approved bending equipment. The use of spot heating devices will not be permitted (i.e. blow torches).

3. A run of conduit shall not contain more than the equivalent of four (4) quarter bends (360°), including those bends located immediately at the outlet or body.

4. Telecommunications conduits shall have no more than two (2) 90-degree bends between pull points and contain no continuous sections longer than 100 feet. Insert pull points or pull boxes for conduits exceeding 100 feet in length.

   a. A third bend is acceptable if:

      1) The total run is not longer than (33) feet.
      2) The conduit size is increased to the next trade size.

5. Telecommunications pull boxes shall not be used in lieu of a bend. Align conduits that enter the pull box from opposite ends with each other. Pull box size shall be twelve (12) times the diameter of the largest conduit. Slip sleeves or gutters can be used in place of a pull box.

6. Telecommunications conduit bend radius shall be six (6) times the diameter for conduits under 2” and ten (10) times the diameter for conduits over 2”.

7. Rigid polyvinyl chloride conduit (PVC) runs longer than 100 feet or runs which have more than two 90° equivalent bends (regardless of length) shall use rigid metal or RTRC factory elbows for bends.

8. Use conduit bodies to make sharp changes in direction (i.e. around beams).

D. Conduit Placement:

1. Conduit shall be mechanically continuous from source of current to all outlets. Conduit shall be electrically continuous from source of current to all outlets, unless a properly sized grounding conductor is routed within the conduit. All metallic conduits shall be bonded per the NEC.

2. Route exposed conduit and conduit above suspended ceilings (accessible or not) parallel/perpendicular to the building structural lines, and as close to building structure as possible. Wherever possible, route horizontal conduit runs above water and steam piping.

3. Route conduit through roof openings provided for piping and ductwork where possible. If not provided or routing through provided openings is not possible, route through roof jack with pitch pocket. Coordinate roof penetrations with other trades.

4. Conduits, raceway, and boxes shall not be installed in concealed locations in metal deck roofing or less than 1.5” below bottom of roof decking.

5. Avoid moisture traps where possible. Where unavoidable, provide a junction box with drain fitting at conduit low point.

6. All conduits through walls shall be grouted or sealed into openings. Where conduit penetrates firewalls and floors, seal with a UL listed sealant. Seal penetrations with intumescent caulk, putty, or sheet installed per manufacturer's recommendations. All materials used to seal penetrations of firewalls and floors shall be tested and certified as a system per ASTM E814 Standard for fire tests or through-penetration fire stops as manufactured by 3M or approved equal.

7. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL OPENINGS REQUIRED IN MASONRY OR EXTERIOR WALLS UNDER THIS DIVISION. A QUALIFIED MASON AT THE EXPENSE OF THIS CONTRACTOR SHALL REPAIR ALL OPENINGS TO MATCH EXISTING CONDITIONS.

8. Seal interior of conduit at exterior entries, air handling units, coolers/freezers, etc., and where the temperature differential can potentially be greater than 20°F, to prevent moisture penetration. Seal shall be placed where conduit enters warm space. Conduit seal fitting shall be a drain/seal, with sealing compound, equal to O-Z/Gedney type EYD.

9. Horizontal conduit routing through slabs above grade:

    a. No conduits are allowed to be routed horizontally through slabs above grade.

10. Do not route conduits across each other in slabs on grade.

11. Rigid polyvinyl chloride conduit (PVC) shall be installed when material surface temperatures and ambient temperature are greater than 40°F.

12. Where rigid polyvinyl chloride conduit (PVC) is used below grade, in a slab, below a slab, etc., a transition to rigid galvanized steel or PVC-coated steel conduit shall be installed before conduit exits earth. The metallic conduit shall extend a minimum of 6" into the surface concealing the non-metallic conduit.

13. Contractor shall provide suitable mechanical protection around all conduits stubbed out from floors, walls or ceilings during construction to prevent bending or damaging of stubs due to carelessness with construction equipment.

14. Contractor shall provide a polypropylene pull cord with 2000 lbs. tensile strength in each empty conduit (indoor and outdoor), except in sleeves and nipples.

15. Telecommunications conduits that protrude through the structural floor shall be installed 1 to 3" above finished floor (AFF).

16. Telecommunications conduits that enter into Telecommunications rooms below the finished ceiling shall terminate a minimum of 4" below ceiling and as close to the wall as possible.

17. Telecommunications conduits that are below grade and enter into a building shall terminate a minimum of 4" above finished floor (AFF) and as close to the wall as possible.

3.5 CONDUIT TERMINATIONS

A. Where conduit bonding is indicated or required in the contract documents, the bushings shall be a grounding type sized for the conduit and ground bonding conductor as manufactured by O-Z/Gedney, Appleton, Thomas & Betts, Burndy, Regal, or approved equal.

B. Conduits with termination fittings shall be threaded for one (1) lock nut on the outside and one (1) lock nut and bushing on the inside of each box.

C. Where conduits terminate in boxes with knockouts, they shall be secured to the boxes with lock nuts and provided with approved screw type tinned iron bushings or fittings with plastic inserts.

D. Where conduits terminate in boxes, fittings, or bodies with threaded openings, they shall be tightly screwed against the shoulder portion of the threaded openings.

E. Conduit terminations to all motors shall be made with flexible metallic conduit (FMC), unless noted otherwise. Final connections to roof exhaust fans, or other exterior motors and motors in damp or wet locations shall be made with liquidtight flexible metallic conduit (LFMC). Motors in hazardous areas, as defined in the NEC, shall be connected using flexible conduit rated for the environment. Flexible conduit shall not exceed 6' in length. Route equipment ground conductors from circuit ground to motor ground terminal through flexible conduit.

F. Rigid polyvinyl chloride conduit (PVC) shall be terminated using fittings and bodies produced by the manufacturer of the conduit, unless noted otherwise. Prepare conduit as per manufacturer's recommendations before joining. All joints shall be solvent welded by applying full even coat of plastic cement to the entire areas that will be joined. Turn the conduit at least a quarter to one half turn in the fitting and let the joint cure for 1-hour minimum or as per the manufacturer's recommendations.

G. All conduit ends shall be sealed with plastic immediately after installation to prevent the entrance of any foreign matter during construction. The seals shall be removed and the conduits blown clear of all foreign matter prior to any wires or pull cords being installed.

3.6 UNDERGROUND CONDUIT INSTALLATION

A. Conduit Connections:

1. Conduit joints in a multiple conduit run shall be staggered at least one foot apart.

B. Conduit Bends (Lateral):

1. Conduits shall have long sweep radius elbows instead of standard elbows wherever special bends are indicated and noted on the drawings, or as required by the manufacturer of the equipment or system being served.

2. Telecommunications conduit bend radius shall be six times the diameter for conduits under 2" and ten times the diameter for conduits over 2". Where long cable runs are involved, sidewall pressures may require larger radius bends. Coordinate with Architect/Engineer prior to conduit installation to determine bend radius.

C. Conduit Elbows (vertical):

1. Minimum metal or RTRC elbow radiuses shall be 30 inches for primary conduits (>600V) and 18 inches for secondary conduits (<600V). Increase radius, as required, based on pulling tension calculation requirements.

D. Conduit Placement:

1. Conduit runs shall be pitched a minimum of 4" per 100 feet to drain toward the terminations. Duct runs shall be installed deeper than the minimum wherever required to avoid any conflicts with existing or new piping, tunnels, etc.

2. For parallel runs, use suitable separators and chairs installed not greater than 4' on centers. Band conduit together with suitable banding devices. Securely anchor conduit to prevent movement during concrete placement or backfilling.

3. Where concrete is required, the materials for concreting shall be thoroughly mixed to a minimum f'c = 2500 and immediately placed in the trench around the conduits. No concrete that has been allowed to partially set shall be used.

4. Before the Contractor pulls any cables into the conduit he shall have a mandrel 1/4" smaller than the conduit inside diameter pulled through each conduit and if any concrete or obstructions are found, the Contractor shall remove them and clear the conduit. Spare conduit shall also be cleared of all obstructions.

5. Conduit terminations in manholes, masonry pull boxes, or masonry walls shall be with malleable iron end bell fittings.

6. All spare conduits not terminated in a covered enclosure shall have its terminations plugged as described above.

7. Ductbanks and conduit shall be installed a minimum of 24" below finished grade, unless otherwise noted on the drawings or elsewhere in these specifications.

8. All non-metallic conduit installed underground outside of a slab shall be rigid.

E. Horizontal Directional Drilling:

1. Entire drill path shall be accurately surveyed, with entry and exit stakes placed and coordinated with other contractors. If using a magnetic guidance system, entire drill path shall be surveyed for any surface geo-magnetic variations or anomalies.

2. Any utility locates within 20 feet of the bore path shall have the exact location physically verified by hand digging or vacuum excavation. Restore inspection holes to original condition after verification.

F. Raceway Seal:

1. Where a raceway enters a building or structure, it shall be sealed with a sealing bushing or duct seal to prevent the entry of liquids or gases. Seal must be compatible with conductors and raceway system. Spare or unused raceway shall also be sealed.

2. All telecommunications conduits and innerducts, including those containing cables, shall be plugged at the building and vault with “JackMoon” or equivalent duct seal, capable of withstanding a 10-foot head of water (5 PSI).

3.7 CONDUIT INSTALLATION SCHEDULE

A. In the event the location of conduit installation represents conflicting installation requirements as specified in the following schedule, a clarification shall be obtained from the Architect/Engineer. If This Contractor is unable to obtain a clarification as outlined above, concealed rigid galvanized steel conduit installed per these specifications and the NEC shall be required.

B. The following schedule shall be adhered to unless they constitute a violation of applicable codes or are noted otherwise on the drawings. The installation of RMC conduit will be permitted in place of all conduit specified in this schedule.

1. Exposed:

   a. Switchboards, panel feeders, etc.: EMT.

   b. Branch Circuits (lighting, receptacles, controls, etc.): EMT.

   c. Mechanical Equipment Feeders (pumps, AHUs, chillers, etc.): EMT.

   d. Floor Mounted Pump Feeders: EMT with no more than 6’ of PVC coated flexible metal conduit to pump.

   e. Controls: EMT painted blue or dyed blue.

2. Finished Spaces/Concealed: EMT.

3. Wet or Damp Locations: RMC conduit, boxes and fittings, installed and equipped to prevent water from entering the conduit system.

4. Corrosive Locations: PVC Coated Rigid Metal conduit, boxes and fittings installed and equipped to prevent water from entering the conduit system.

5. In or Under Slabs on Grade:

   a. Within 5’ from the perimeter of the building: RMC

   b. Within 5’ from the perimeter of the building when passing through the perimeter of the building foundation: RMC conduit with a minimum of 3" thickness between the surface of the concrete and the nearest conduit. Concrete to be doweled into the foundation.

6. Site Conduits:

   a. Within 5' from the Perimeter of a Building Foundation: RMC conduit with a minimum of 3" thickness between the surface of the concrete and the nearest conduit. Concrete to be doweled into the foundation.

   b. 5' or Greater from the Perimeter of a Building Foundation: RMC.

   c. Under Roads, Drives, and Vehicle Traveled Ways: Concrete encased PVC with a minimum of 3” concrete cover on all sides of conduit.

7. Interior Locations:

   a. Exposed: EMT conduit.

      1) Exposed Controls Conduit: EMT painted blue or dyed blue.

   b. Concealed: EMT.

8. Hazardous Locations as Defined by the NEC: RMC conduit complete with screwed fittings and conduit seals.

3.8 BOX INSTALLATION SCHEDULE

A. Galvanized steel boxes may be used in:

   1. Concealed interior locations above ceilings and in hollow studded partitions.
   2. Exposed interior locations in mechanical rooms and in rooms without ceilings; higher than 8' above the highest platform level.
   3. Direct contact with concrete except slab on grade.
   4. Recessed in stud wall of kitchens and laundries.

B. Cast boxes shall be used in:

   1. Exterior locations.
   2. Hazardous locations.
   3. Exposed interior locations within 8' of the highest platform level.
   4. Direct contact with earth.
   5. Direct contact with concrete in slab on grade.
   6. Wet locations.
   7. Kitchens and laundries when exposed on wall surface.

3.9 COORDINATION OF BOX LOCATIONS

A. Provide electrical boxes as shown on the drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.

B. Electrical box locations shown on the Contract Drawings are approximate, unless dimensioned. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.

C. Locate and install boxes to allow access. Avoid interferences with ductwork, piping, structure, equipment, etc. Where installation is inaccessible, provide access doors. Coordinate locations and sizes of required access doors with the Architect/Engineer and General Contractor.

D. Locate and install to maintain headroom and to present a neat appearance.

E. Coordinate locations with Heating Contractor to avoid baseboard radiation cabinets.

3.10 OUTLET BOX INSTALLATION

A. Do not install boxes back-to-back in walls.

1. Provide a minimum horizontal separation of 6 inches between boxes installed on opposite sides of non-rated stud walls. When the minimum separation cannot be maintained, install sound insulation pads on all five sides of the back box in accordance with the manufacturer's instructions.

2. Provide a minimum horizontal separation of 24 inches between boxes installed on opposite sides of fire-rated walls. When the minimum separation cannot be maintained, the box is greater than 16 square inches or the total box area (all trades) per 100 square feet is greater than or equal to 100 square inches, install fire-rated moldable pads to all five sides of the back box to maintain the fire rating of the wall. Install moldable pads in accordance with UL listing for the specific product. Sound insulation pads are not acceptable for use in fire-rated wall applications unless the product carries the necessary fire rating.

B. Install sound insulation pads on all five sides of the back of all boxes in sound-rated wall assemblies. Sound-rated wall assemblies are defined as partition types carrying a Sound Transmission Class (STC) rating.

C. The Contractor shall anchor switch and outlet box to wall construction so that it is flush with the finished masonry, paneling, drywall, plaster, etc. The Contractor shall check the boxes as the finish wall surface is being installed to assure that the box is flush. (Provide plaster rings as necessary.)

D. Mount at heights shown or noted on the drawings or as generally accepted if not specifically noted.

E. Locate boxes in masonry walls to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat openings for boxes.

F. Provide knockout closures for unused openings.

G. Support boxes independently of conduit.

H. Use multiple-gang boxes where more than one device is mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.

I. Install boxes in walls without damaging wall insulation.

J. Coordinate mounting heights and locations of outlets mounted above counters, benches, backsplashes, and below baseboard radiation.

K. Position outlets to locate luminaires as shown on reflected ceiling drawings.

L. In inaccessible ceiling areas, position outlets and junction boxes within 6 inches of recessed luminaire, to be accessible through luminaire ceiling opening.

M. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioned to allow for surface finish thickness. Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.

N. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

O. Provide cast outlet boxes in exterior locations and wet locations, and where exposed rigid or intermediate conduit is used.

3.11 PULL AND JUNCTION BOX INSTALLATION

A. Locate pull boxes and junction boxes above accessible ceilings or in unfinished areas.

B. Support pull and junction boxes independent of conduit.

C. Do not install boxes back-to-back in walls.

1. Provide a minimum horizontal separation of 6 inches between boxes installed on opposite sides of non-rated stud walls. When the minimum separation cannot be maintained, install sound insulation pads on all five sides of the back box in accordance with the manufacturer's instructions.

2. Provide a minimum horizontal separation of 24 inches between boxes installed on opposite sides of fire-rated walls. When the minimum separation cannot be maintained, the box is greater than 16 square inches or the total box area (all trades) per 100 square feet is greater than or equal to 100 square inches, install fire-rated moldable pads to all five sides of the back box to maintain the fire rating of the wall. Install moldable pads in accordance with UL listing for the specific product. Sound insulation pads are not acceptable for use in fire-rated wall applications unless the product carries the necessary fire rating.

D. Install sound insulation pads on all five sides of the back of all boxes in sound-rated wall assemblies. Sound-rated wall assemblies are defined as partition types carrying a Sound Transmission Class (STC) rating.

3.12 EXPOSED BOX INSTALLATION

A. Boxes shall be secured to the building structure with proper size screws, bolts, hanger rods, or structural steel elements.

B. On brick, block and concrete walls or ceilings, exposed boxes shall be supported with no less than two (2) Ackerman-Johnson, Paine, Phillips, or approved equal screw anchors or expansion shields and round head machine screws. Cast boxes shall not be drilled.

C. On steel structures, exposed boxes shall be supported to the steel member by drilling and tapping the member and fastening the boxes by means of round head machine screws.

D. Boxes may be supported on steel members by APPROVED beam clamps if conduit is supported by beam clamps.

E. Boxes shall be fastened to wood structures by means of a minimum of two (2) wood screws adequately large and long to properly support. (Quantity depends on size of box.)

F. Wood, plastic, or fiber plugs shall not be used for fastenings.

G. Explosive devices shall not be used unless specifically allowed.

END OF SECTION

SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Adhesive labels, markings, nameplates, and signs
B. Wire and cable markers
C. Raceway, box, and wire identification
D. Equipment short circuit current rating (SCCR) labeling
E. Electrical equipment labeling
F. Electrical working clearance identification
G. Pole identification

1.2 REFERENCES

A. ANSI C2 – National Electrical Safety Code
B. NFPA 70 – National Electrical Code (NEC)
C. ANSI A13.1 – Standard for Pipe Identification
D. ANSI Z535.4 – Standard for Product Safety Signs and Labels

PART 2 - PRODUCTS

2.1 ADHESIVE MARKINGS AND FIELD LABELS

A. Adhesive Marking Labels for Raceway: Pre-printed, flexible, self-adhesive vinyl labels with legend indicating voltage and service (Emergency, Lighting, Power, HVAC, Communications, Control, Fire).

1. Label Size as follows:

a. Raceways: Kroy or Brother labels 1-inch (25mm) high by 12-inches (305mm) long (minimum).

2. Color: As specified for various systems.

B. Colored Adhesive Marking Tape for banding Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch (25mm) to 2 inches (50mm) in width.

C. Pretensioned Flexible Wraparound Colored Plastic Sleeves for Cable Identification: flexible acrylic bands sized to suit the cable diameter and arranged to stay in place by pre-tensioned gripping action when coiled around the cable.

D. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound, cable/conductor markers with preprinted numbers and letter.

E. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch (5mm) minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from minus 50°F to 350°F (10°C to 176°C). Provide ties in specified colors when used for color coding.

F. Underground Plastic Markers: Bright colored continuously printed plastic ribbon tape of not less than 6 inches wide by 4 mil thick, printed legend indicating type of underground line, manufactured for direct burial service. Tape shall contain a continuous metallic wire to allow location with a metal detector.

G. Aluminum, Wraparound Marker Bands: 1-inch (25mm) width, 0.014 (5mm) inch thick aluminum bands with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

H. Brass or aluminum Tags: 2" (50mm) by 2" (50mm) by .05-inch (2mm) metal tags with stamped legend, punched for fastener.

I. Indoor/Outdoor Number and Letters: Outdoor grade vinyl label with acrylic adhesive designed for permanent application in severe indoor and outdoor environments.

J. Text Sizes:

1. The following information shall be used for text heights, fonts, and size, unless otherwise noted.

a. Font: Normal 721 Swiss Bold
b. Adhesive Labels: 3/16 inch (5mm) minimum text height
c. Vinyl / Plastic Laminate Labels: 3/4" inch (19mm) minimum text height

2.2 NAMEPLATES AND SIGNS

A. Engraved, Plastic-Laminated Labels, Signs and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch (2mm) minimum thick for signs up to 20 square inches (13 square cm), or 8 inches (200mm) in length; 1/8 inch (3mm) thick for larger sizes. Labels shall be punched for mechanical fasteners.

B. Text Sizes:

1. The following information shall be used for text heights, fonts, and size, unless otherwise noted.

a. Text Height: 3/8 inch (10mm) minimum

C. Baked–Enamel Signs for interior Use: Preprinted aluminum signs, punched, or drilled for fasteners, with colors, legend, and size required for application. Mounting ¼" grommets in corners.

D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396 inch (10mm) galvanized-steel backing: and with colors, legend, and size required for application. Mounting 1/4" grommets in corners.

E. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

F. Fasteners for Plastic-Laminated Signs; Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.

2.3 PRODUCT COLORS

A. Adhesive Markings and Field Labels:

1. All Labels: Black letters on white face

B. Nameplates and Signs:

1. NORMAL POWER: Black letters on white face
2. EMERGENCY: White letters on red face
3. GROUNDING: White letters on green face.
4. CAUTION or UPS: Black letters on yellow face

C. Raceways and Conduit:

1. Provide color coded conduit as indicated below. Conduit shall be colored by the manufacturer:

   a. Normal Power and General Distribution: Silver
   b. Emergency Power Distribution System:

      1) All Emergency: Orange

   c. Temperature Controls: Blue
   d. Ground: Green
   e. Low Voltage and Telephone: Purple
   f. Clock, Sound, Security System, and Intercom: Black

D. Box Covers:

1. Box cover colors shall match conduit colors listed above.

E. Conductor Color Identification: Refer to Part 3 for additional information.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as required by code.

B. Electrical System Color Chart: This Contractor shall furnish and install framed 8" x 12" charts of the color-coded identification scheme used for the electrical system in all electrical rooms and next to the main fire alarm panel.

C. Install identification devices in accordance with manufacturer’s written instruction and requirements of NEC.

D. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work. All mounting surfaces shall be cleaned and degreased prior to identification installation.

E. Circuit Identification: Tag or label conductors as follows:

1. Multiple Power or Lighting Circuits in Same Enclosure: Where multiple branch circuits are terminated or spliced in a box or enclosure, label each conductor with source and circuit number.

2. Multiple Control Wiring and Communication/Signal Circuits in Same Enclosure: For control and communications/signal wiring, use wire/cable marking tape at terminations in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tape.

3. Match identification markings with designations used in panelboards shop drawings, Contract Documents, and similar previously established identification schemes for the facility’s electrical installations.

F. Apply warning, caution and instruction signs as follows:

1. Install warning, caution or instruction signs where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.

2. Emergency Operating Signs: Install, where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect, engraved laminate signs with white legend on red background with minimum 3/8-inch (10mm) high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.

G. Apply circuit/control/item designation labels of engraved plastic laminate for pushbuttons, pilot lights, alarm/signal components, and similar items, except where labeling is specified elsewhere.

H. Install labels parallel to equipment lines at locations as required and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

I. Install ARC FLASH WARNING signs on all power distribution equipment per Section 26 05 73.

J. Circuits with more than 600V: Identify raceway and cable with "DANGER—HIGH VOLTAGE" in black letters 2 (50mm) inches high on orange background at 10'-0 foot (3m) intervals.

1. Entire floor area directly above conduits running beneath and within 12 inches (305mm) of a basement or ground floor that is in contact with earth or is framed above unexcavated space.

2. Wall surfaces directly external to conduits concealed within wall.

3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in building, or concealed above suspended ceilings.

K. Underground Electrical Lines: For exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 (150mm) to 8 (205mm) inches below grade. A single plastic line marker is permitted when the width of the common trench does not exceed 16 inches (405mm); provide a second plastic line marker to mark each edge of the trench when 16 inches (405mm) of width is exceeded. Install line marker for underground wiring, both direct-buried cables and cables in raceway.

3.2 LIGHTING CONTROL AND RECEPTACLE COVER PLATES

A. Product:

1. Adhesive labels and field markings
2. Nameplates and signs

B. Identification material to be a clear, 3/8-inch (10mm) Kroy tape or Brother self-laminating vinyl label with black letters. Embossed Dymo-Tape labels are not acceptable. Permanently affix identification label to cover plates, centered above the receptacle openings.

C. Provide identification on all switch and receptacle cover plates. Identification shall indicate source and circuit number serving the device (e.g. “C1A #24”).

3.3 CONDUIT AND EXPOSED CABLE LABELING

A. Product:

1. Adhesive labels and field markings

B. Conduit Identification: Pre-printed, flexible, self-adhesive vinyl labels with legend at 25 foot (7.5 meter) intervals to identify all conduits run exposed or located above accessible ceilings. Conduits located above non-accessible ceiling or in floors and walls shall be labeled within 3 feet of becoming accessible. Labels for multiple conduits shall be aligned. Refer to color requirements in Part 2 when applicable in addition to the following:

1. 1000 Volt or less Normal/Emergency Power: Indicate feeder identification and voltage.
2. Grounding: Indicate “GROUND” and equipment and designation.
3. Security System: Indicate "Security".
4. Telephone System: Indicate “Telephone".

C. Blank conduit ends or outlet boxes for future extension of system shall have permanent identification marker indicating purpose of conduit or box and where the raceway originated.

3.4 BOX LABELING

A. Products:

1. Adhesive labels and field markings

B. Identify Junction, Pull and Connection Boxes: Labeling shall be 3/8-inch (10mm) Kroy tape or Brother self-laminating vinyl label, letters/numbers color coded same as conduits. In rooms that are painted out, provide labeling on inside of cover.

C. All junction, pull, and connection boxes shall be identified as follows:

1. For power and lighting circuits, indicate system voltage and identity of contained circuits (“120V, 1LA1-3,5,7”).

2. For other wiring, indicate system type and description of wiring (“FIRE ALARM NAC #1”).

3.5 CONDUCTOR COLOR CODING

A. Color coding shall be applied at all panels, switches, junction boxes, pull boxes, vaults, manholes etc., where the wires and cables are visible and terminations are made. The same color coding shall be used throughout the entire electrical system, therefore maintaining proper phasing throughout the entire project.

B. All wires and cables shall be color coded by the manufacturer.

C. Colored cable ties shall be applied in groups of three ties of specified color to each conductor at each terminal or splice point starting 3 inches (76mm) from the termination and spaced at 3- inches (76mm) centers. Tighten to a snug fit, and cut off excess length.

D. Where more than one nominal voltage system exists in a building or facility, each ungrounded conductor of a multi-wire branch circuit, where accessible, shall be identified by phase and system.

E. Conductors shall be color coded as follows:

1. 120/240 Volt, 3-Wire:

   a. A-Phase – Black
   b. B-Phase – Red
   c. Neutral – White
   d. Ground Bond – Green

2. 208Y/120 Volt, 4-Wire:

   a. A-Phase – Black
   b. B-Phase – Red
   c. C-Phase – Blue
   d. Neutral – White
   e. Ground Bond – Green

3. 480Y/277 Volt, 4-Wire:

   a. A-Phase – Brown
   b. B-Phase – Orange
   c. C-Phase – Yellow
   d. Neutral – Gray
   e. Ground Bond – Green

4. 120 Volt, 2-Wire Isolated (Ungrounded) Power System:

   a. A-Phase – Orange with distinctive colored stripe other than white, green or gray along the entire length of the conductor
   b. B-Phase – Brown with distinctive colored stripe other than white, green or gray along the entire length of the conductor
   c. Ground Reference – Green

5. 120/208 Volt, 3-Wire, Isolated (Ungrounded) Power System:

   a. A-Phase – Orange with distinctive colored stripe other than white, green or gray along the entire length of the conductor
   b. B-Phase – Brown with distinctive colored stripe other than white, green or gray along the entire length of the conductor
   c. C-Phase – Yellow with distinctive colored stripe other than white, green or gray along the entire length of the conductor
   d. Ground Reference – Green

6. 60 to 1500 Volt, Direct Current DC Power System:

   a. Positive Polarity: Red or black with permanent red stripe marked along the entire length. Provide shrink wrap sleeves at terminations indication (POS, POSITIVE, or POS (+).

   b. Negative Polarity: Black. Provide shrink wrap sleeves at terminations indication (NEG, NEGATIVE, or NEG (-).

7. Isolated Equipment Ground Conductors: Green with colored distinctive yellow stripe along the entire length of the conductor.

3.6 CONTROL EQUIPMENT IDENTIFICATION

A. Products:

   1. Nameplates and signs

B. Provide identification on the front of all control equipment such as combination starters, starters, VFDs, contactors, motor control centers, etc.

C. Identification shall be provided for all connections to equipment furnished by this Contractor, other contractors, or the Owner.

D. Labeling shall include:

   1. Equipment type and contract documents designation of equipment being served.
   2. Location of equipment being served if it is not located within sight.
   3. Voltage and phase of circuit(s).
   4. Panel and circuit number(s) serving the equipment.
   5. Method of automatic control, if included ("AUTO CONTROL BY FCMS").
   6. Available fault current; refer to one-line diagram or panel schedule of panel serving equipment.

7. Date of fault current study, refer to one-line diagram

EXHAUST FAN EF-1 ("LOCATED ON ROOF") 480V, 3-PHASE FED FROM “1HA1-1” AUTO CONTROL BY FCMS 22,000 AMPS AVAILABLE FAULT CURRENT DATE OF STUDY: 1 JAN 2017

3.7 EQUIPMENT CONNECTION IDENTIFICATION

A. Products:

1. Nameplates and signs

B. Provide identification for hard wired electrical connections to equipment such as disconnects switches, starters, etc. Plug and cord type connections do not require this specific label.

C. Identification shall be provided for all connections to equipment furnished by this Contractor, other contractors, or the Owner.

D. Labeling shall include:

1. Equipment type and contract documents designation of equipment being served
2. Location of equipment being served if it is not located within sight.
3. Voltage and rating of the equipment.
4. Panel and circuit numbers(s) serving the equipment
5. Available fault current; refer to one-line diagram or panel schedule of panel serving equipment.
6. Date of fault current study; refer to one-line diagram

UNIT HEATER UH-1 (“LOCATED IN STORAGE ROOM 200”) 480V: 3-PHASE FED FROM “1HA1-1” 22,000 AMPS AVAILABLE FAULT CURRENT DATE OF STUDY: 1 JAN 2017

3.8 POWER DISTRIBUTION EQUIPMENT IDENTIFICATION

A. Products:

1. Nameplates and signs

B. Provide identification on the front of all power distribution equipment such as panelboards, switchboards, switchgear, motor control centers, generators, UPS, storage battery disconnects, transfer switches, etc. Labels shall be visible on the exterior of the gear, correspond to the one-line diagram nomenclature, and identify each cubicle of multi-section gear.

1. Interior Equipment: The identification material shall be engraved plastic-laminated labels.

2. Exterior Equipment: The identification material shall be engraved vinyl labels.

3. Labeling shall include:

   a. Equipment type and contract documents designation of equipment.
   b. Voltage of the equipment.
   c. Name of the upstream equipment and location of the upstream equipment if it is not located within sight.
   d. Rating and type of the overcurrent protection device serving the equipment if it is not located within sight ("FED BY 400A/3P BREAKER").

DISTRIBUTION PANEL DP-H1 480Y/277V FED FROM SWITCHBOARD “SB-1” (LOCATED IN MAIN ELEC ROOM)

4. Provide the following on a separate label, installed below the label above:

   a. Available fault current; refer to one-line diagram or panel schedules
   b. Date of fault current study; refer to one-line diagram

22,000 AMPS AVAILABLE FAULT CURRENT DATE OF STUDY: 1 JAN 2017

C. Service Equipment Label: A separate nameplate for the service entrance equipment and include:

1. Nominal system voltage
2. Maximum available fault current; refer to one-line diagram for values
3. Clearing time of overcurrent protection devices based on available fault current. Refer to calculations and report from Section 26 05 73 for value.
4. Date of fault current study; refer to one-line diagram
5. Date of label

480Y/277V 39,800 AMPS AVAILABLE FAULT CURRENT 0.07 SECOND CLEARING TIME DATE OF STUDY: 1 JAN 2017 DATE OF LABEL: 4 JUL 2017

D. Arc Energy Reduction Label:

1. Provide a separate engraved plastic laminate label centered at the top of each vertical section of the electrical gear indicating the following when applicable.

   a. Label: “This equipment is designed with a system listed below”.

b. Applicable Systems:

1) Zone-selective interlocking system for selective coordination and arc energy reduction
2) Differential relaying system for selective coordination and arc energy reduction
3) Arc energy reducing maintenance switch
4) Energy reducing active arc flash mitigation system

E. Nominal System Voltage Label:

1. Where more than one nominal voltage system exists in a building or facility, the identification of color coding used in the panelboard or equipment shall be permanently posted on the interior of the door or cover.

F. Distribution panelboards and switchboards shall have each overcurrent protection device identified with name and location of the load being served ("AHU-1 LOCATED IN PENTHOUSE 1").

G. Branch panelboards shall be provided with typed panel schedules upon completion of the project. Existing panelboards shall have their existing panel schedules typed, with all circuit changes, additions or deletions also typed on the panel schedules. A copy of all panel schedules for the project shall be turned over as part of the O&M Manuals. Refer to Section 26 05 00 for other requirements.

3.9 INDUSTRIAL CONTROL PANEL IDENTIFICATION

A. Products:

1. Nameplates and signs

B. Provide identification on the front of all industrial control panels and similar equipment. Labels shall be visible on the exterior of the gear and correspond to the one-line and/or schematic diagram nomenclature.

1. Interior equipment: The identification material shall be engraved plastic-laminated labels.
2. Labeling shall include:

a. Equipment type and contract documents designation of equipment.
b. Manufacturer / Assembler of industrial control panel
c. Voltage, phase, frequency, full load current of each supply circuit
d. Name of the upstream equipment and location of the upstream equipment if it is not located within sight.
e. Rating and type of the overcurrent protection device serving the equipment if it is not located within sight ("FED BY 400A/3P BREAKER").

INDUSTRIAL CONTROL PANEL ICP-1 ABC COMPANY 480V, 3PHASE, 60HZ, 60A (PANEL E1-1 LOCATED IN ELEC 123) 120V, 1PHASE, 60HZ, 20A (PANEL E2-1 LOCATED IN ELEC 123) 22,000 SHORT CIRCUIT RATING

C. Nominal System Voltage Label:

1. Where more than one nominal voltage system exists in a building or facility, the identification of color coding used shall be permanently posted on the interior of the door or cover of the industrial control panel.

D. Schematic Diagram: Provide a laminated copy of the industrial control panel schematic wiring diagram. Post the diagram on the inside cover of the control panel.

E. Service Equipment Label: Refer to Electrical Distribution Equipment - Service Equipment Label of this specification if applicable for additional requirements.

3.10 TRANSFORMER EQUIPMENT IDENTIFICATION

A. Products:

1. Nameplates and signs

B. Provide identification on the front of all transformers. The identification nameplate shall be an engraved plastic-laminated label.

C. Labeling shall include:

1. Equipment type and contract documents designation of equipment
2. Name of the upstream equipment.
3. Voltage and rating of the equipment.
4. Location of the upstream equipment if it is not located within sight.

TRANSFORMER TR-15 480V: 208Y/120V 15KVA FED FROM SWITCHBOARD "SB-1" (LOCATED IN ELEC 123)

3.11 ELECTRICAL WORKING CLEARANCE IDENTIFICATION

A. Products:

1. Safety Yellow paint and custom stencils

B. Provide custom identification of electrical equipment working clearances in all areas.

C. Identification shall include a painted rectangular box (on the finished floor) in front of the electrical equipment to define the code-required working clearance. Provide additional diagonal stripping inside the rectangle box. All painted stripping shall be safety yellow paint with 3 inch (76mm) wide stripes.

1. Width of area: Width of equipment or as required by code
2. Depth of area: Depth as required by code

3.12 POLE IDENTIFICATION

A. Product:

1. Adhesive labels and field markings
2. Nameplates and signs

B. Lighting poles, bollards and overhead distribution poles shall be individually identified with a unique number, for maintenance purposes. Apply the vinyl label number above the hand hole cover or 24” (610mm) above grade. Bollards may be identified with a number applied inside the luminaire that is visible from the exterior.

END OF SECTION

SECTION 26 05 73

POWER SYSTEM STUDY

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Low voltage distribution system power study.
B. Short-circuit analysis and report.
C. Selective coordination analysis and report.
D. Arc-flash hazard analysis and report.

1.2 RELATED SECTIONS

A. Section 26 05 00 - Basic Electrical Requirements
B. Section 26 24 13 - Switchboards
C. Section 26 24 16 - Panelboards
D. Section 26 33 53 - Static Uninterruptible Power Supply

1.3 SUBMITTALS

A. Analyses shall be performed by an agent authorized by the manufacturer of equipment specified in the related specification sections and shall bear the seal/signature of the licensed Professional Engineer who performed the analysis.

B. The input for the power system study shall be based on the contract documents, with estimated conductor lengths provided by the Electrical Contractor. IMEG will provide a preliminary Power Tools for Windows project file for information, if requested.

C. Documentation of the analyses shall be submitted in a bound booklet format and shall accompany the shop drawing submittals for equipment provided under the related work specification sections. These shop drawings will not be reviewed without this documentation. Submit a sample arc-flash hazard label for Owner review and approval prior to printing.

D. Power system study project model shall be submitted on electronic media for review and the Owner’s operating and maintenance records.

1.4 SCOPE

A. Provide a power system study of the electrical system shown on the plans. The study shall include arc-fault analysis, selective coordination analysis and arc flash hazard analysis.

B. Contractor is required to provide a fully coordinated system for the essential electrical system and the associated normal side of each transfer switch and all other locations indicated on the one line diagram. Contractor shall provide overcurrent protective devices with the appropriate models, frame sizes, trip units, etc. as required to provide a selectively coordinated system.

PART 2 - PRODUCTS

2.1 Power systems study shall be completed in Power Tools for Windows **(PTW) 8.0** or later version or pre-approved equivalent program**.**

PART 3 - EXECUTION

3.1 SHORT-CIRCUIT ANALYSIS

A. Provide a complete short-circuit analysis from the utility service to and including the entire building distribution as shown on the drawings.

B. Analysis shall include the entire distribution system from the point of connection to the utility power source to the distribution panels and branch circuit panelboards.

C. Documentation shall be made in one-line diagram form showing the magnitude and location of each calculated fault. Fault current calculations shall be made at the main bus of each switchboard, distribution panel, and branch circuit panel. A summary of the fault currents available shall also be submitted.

3.2 SELECTIVE COORDINATION ANALYSIS

A. Provide a complete selective coordination analysis, comparing time/current curves of the protective devices to be installed to assure complete selectivity between main and downstream devices for code-required branches and branches identified on one-line drawings. Overcurrent protective devices serving the essential electrical system shall selectively coordinate for the period of time that a fault's duration extends beyond 0.01 second. Overcurrent protective devices serving the normal shall selectively coordinate for the period of time that a fault's duration extends beyond 0.01 second.

B. The analysis shall include primary protective device, secondary main switchboard device(s), switchboard branch feeder devices, generator breaker, distribution panel, panelboard main devices, and branch feeder devices.

C. The coordination plots provided shall indicate graphically the coordination proposed for the system on full-size log forms and shall define the types of protective devices selected, together with proposed time dial and pickup settings required. The plots shall include titles, representative one-line diagrams, legend, complete parameters for transformer(s), and complete operating bands for circuit breaker trip devices, fuses, etc.

1. The long-time region of the coordination plots shall designate the pickups required for the circuit breakers.

2. The short-time region shall indicate the magnetizing in-rush and ASA-withstand-transformer parameter, the circuit breaker, short-time and instantaneous trip devices, fuse-manufacturing tolerance bands, significant symmetrical fault currents, etc.

3. Each primary protective device required for the transformer shall be selected so the characteristics or operating band is within the transformer parameters, which shall include a parameter equivalent to 58% of the withstand point to afford protection for secondary line-to-ground faults. The transformer damage curve shall be included for the transformer when the selected protective device is not within the associated parameters.

4. Molded case circuit breakers shall be separated from each other and the associated primary protective device by a 16% current margin for coordination and protection in the event of secondary line-to-line faults.

5. Include zone selective interlocking, differential relaying, and other selective coordination technology in the study when required by other specification sections.

6. The protective device characteristics or operating bands shall be suitably indicated to reflect the actual symmetrical fault currents sensed by the device.

7. The drawings and specifications indicate the general requirements for motors, motor-starting equipment, and medium-voltage and low-voltage equipment, but additional specific requirements of equipment furnished shall be determined in accordance with the results of the coordination study.

   a. The study shall include verification of equipment ratings and settings. The Contractor shall keep the study up-to-date with any project changes which affect the study and submit the revised study for review. A final electronic copy shall be submitted with the record drawings.

D. Provide summary table of adjustable overcurrent protective devices settings for the operating and maintenance manual.

3.3 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, unit substations, motor-control centers, panelboards, busway, and splitters) where work could be performed on energized parts.

C. Safe working distances shall be based on the calculated arc flash boundary considering an incident energy of 1.2 cal/cm^2.

D. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit analysis and coordination study models. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations

E. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared, and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

F. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3 to 5 cycles.

2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

G. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

H. Include Arc Energy Reduction (AER) analysis in the study when required by other specification sections.

I. When performing incident energy calculations on the line side of a main breaker (as required per the above), the line side and load side contributions must be included in the fault calculation.

J. Miscoordination should be checked among all devices within the branch containing the immediate protective device upstream of the calculation location, and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

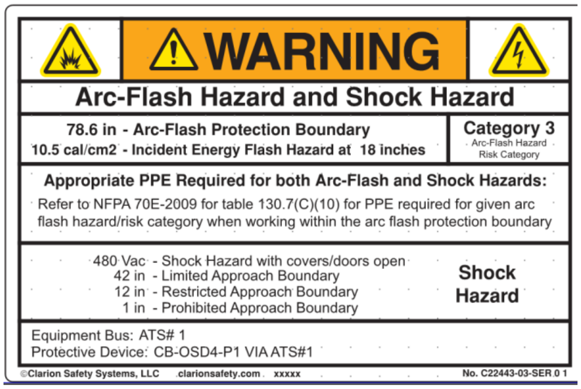
K. Arc flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section.

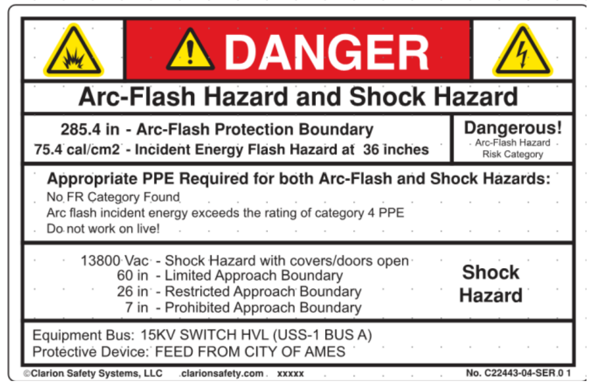
L. Where it is not physically possible to move outside the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

M. Create and install NFPA 70E compliant labels describing the arc flash hazard level at all switchboards, panelboards, and other locations in the electrical distribution system where work could be performed on energized parts.

N. The label shall include the incident energy calculated in the analysis and the hazard category or appropriate personal protective equipment (PPE) required to perform maintenance on the system when energized. Labels shall be vinyl or laminated, with a self-adhesive backing.

O. Examples showing the minimum required information follow:





P. A list of all hazard categories and the corresponding PPE requirements shall be posted in the main electric room, engineering office, or other location. The list shall be plastic laminate or typewritten and housed in a plastic frame.

3.4 ADJUSTMENTS

A. Manufacturer's authorized representative or Contractor shall set all adjustable protective devices to values indicated in the approved coordination study.

B. Wherever the arc flash incident energy exceeds Arc Flash Category 2 (i.e. > 8 cal/cm^2), provide options for adjusting breaker trip times, if possible, to reduce energies to Category 2 or below.

3.5 TRAINING

A. Provide four hours of Owner training to explain the implications of arc-flash requirements and work permit procedure.

END OF SECTION

SECTION 26 09 16

ELECTRICAL CONTROLS AND RELAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Relays
B. Pushbutton Operators
C. Control Power Cabinets

PART 2 - PRODUCTS

2.1 CONTROL RELAYS

A. Mount relays in separate NEMA 4 enclosure or in control terminal cabinet.

B. **[R-#]:** Industrial AC Control Relay:

1. Modular construction, replaceable convertible contacts, 600-volt A.C. contacts, 10-amp continuous rating.

2. Approved Manufacturers: Square D Type X Class 8501, General Electric, Cutler Hammer, Siemens.

C. **[R-#]:** Power Relay:

1. Visible contacts, coil burden less than 10 V.A., 600-volt A.C. contacts, 2 normally open contacts, 30-amp continuous contacts electrically held.

2. Approved Manufacturers: Square D Type C Class 8501 CO, Cutler Hammer, General Electric, Siemens.

D. **[R-#]:** General Purpose Relay:

1. Continuous duty coil, 1 N.O. and 1 N.C. contacts, electrically held, 12-amp, 240 volt rated contacts. Provide compatible plug-in base socket.

2. Approved Manufacturers: Square D Class 8501 Type K, Cutler Hammer, General Electric, Siemens.

2.2 [CPC]: CONTROL POWER CABINET

A. Provide a 12”x8”x4” screw cover NEMA 1 enclosure, single pole specification grade 20-amp switch in a single gang box, fuse block, fuses and equipment for interface of temperature control system. Mount above accessible ceiling.

B. Approved Manufacturers:

1. Enclosure - Hoffman A-SE12X8X4, Weigmann, Hammond Manufacturing
2. Fuseholders - Bussman NDNLDF-WH, Mersen, Littelfuse
3. Neutral Block - Bussman NDNV4-WH, Mersen, Littelfuse

2.3 [ES]: EMERGENCY STOP

A. Red mushroom head, N.C. contact, turn to release, provide engraved nameplate to read "Emergency Shutoff".

1. Approved Manufacturers: Square D XAL K178H7, Cutler Hammer, General Electric, Siemens.

2.4 [EPO]: EMERGENCY POWER OFF

A. Mushroom head, (1) N.O. (1) N.C. contacts, 120 volt, turn to release, provide engraved nameplate to read "Emergency Shutoff". Provide guarded enclosure cover to protect from accidental operation.

1. Approved Manufacturers: Square D 9001 XB5AS8445 - KYG1Y, Cutler Hammer, General Electric, Siemens 52PA2W2A.

2.5 [FA-LA]: LAMP ANNUNCIATOR

A. Four indicators across and one indicator down. Surface mount, 125 volt. Supply with lamp test, lamp reset, and acknowledge buttons. Provide with 1/4" character height.

2.6 [PB]: MOMENTARY PUSHBUTTON

A. Non-illuminated, round 1-3/8" diameter mushroom button, (1) normally open, (1) normally closed contact. Contacts rated 10 amps continuous. Provide 2-1/4" square engraved nameplate with white background and black letters.

1. Approved Manufacturers: Square D Class 9001- SKR4RH13 button, (2) KA1 contacts - KN100WP nameplate.

2.7 [ST]: SHUNT TRIP

A. Trips breaker electrically using a remote 2-wire control source. Verify voltage with application prior to ordering.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with Mechanical Division 23 in connection of control conduit into control terminal cabinet.

B. Install line voltage thermostats for single phase motors. provided by Division 21/22/23.

C. Provide remote control connection to remote devices.

END OF SECTION

SECTION 26 09 33

LIGHTING CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Line and low voltage standalone lighting controls
B. Emergency transfer devices
C. Distributed lighting control
D. Central lighting controls
E. Digital addressable lighting interface (DALI)
F. Architectural dimmer rack and accessories
G. DC dimming systems
H. Time switches

1.2 RELATED WORK

A. Section 1 91 00 - Commissioning
B. Section 23 09 00 - Facility Management Control System (FMCS)
C. Section 26 51 00 - Lighting

1.3 QUALITY ASSURANCE

A. Manufacturers shall be regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. All components and assemblies are to be factory pre-tested prior to delivery and installation.

C. Comply with NEC as applicable to electrical wiring work.

D. Comply with applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.

E. Panels and accessory devices are to be UL listed under UL 916 Energy Management Equipment. Panels and accessories used for control of life safety and critical branch circuits shall be listed under UL 924 Emergency Lighting and Power Equipment.

F. All assemblies are to be in compliance with FCC emissions standards specified in Part 15 Subpart J for Class A applications.

1.4 REFERENCES

A. FCC Rules and Regulations, Part 15, Subpart J - Radio Frequency Interference
B. FS W S 896 Switch, Toggle
C. International Energy Conservation Code (IECC)
D. NEMA WD 1 - General Color Requirements for Wiring Devices
E. NEMA WD 7 - Occupancy Motion Sensors
F. NFPA 70 - National Electrical Code (NEC)
G. UL Standard 916 Energy Management Equipment

H. UL 924 - Emergency Lighting and Power Equipment
I. UL 1472 – Solid-State Dimming Controls

1.5 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Submit a comprehensive package including devices, hardware, software, product specification, finishes, dimensions, installation instructions, warranty, system software requirements.

C. Provide floor plan showing location, orientation, and coverage area of each control device, sensor, and controller/interface. For areas requiring multiple sensor devices for appropriate coverage, submit specific manufacturer-approved sensor layout as an overlay directly on the project drawings, either in print or approved electronic form.

D. Submit a list of devices and equipment that will be installed for each sequence of operation.

E. Submit project specific control wiring diagrams showing all equipment, line voltage, and control wiring requirements for all components including, but not limited to, dimmers, relays, low voltage switches, occupancy sensors, control stations, and communication interfaces and programming instructions for each sequence of operation. Include network cable specification and end-of-line termination details, if required.

1.6 EXTRA STOCK

A. Provide extra stock under provisions of Section 26 05 00.

B. Sensors, Controls, Power Supplies, and Relays: Five (5) percent of quantity installed. Minimum of two (2) of each configuration and type.

1.7 PROJECT RECORD DOCUMENTS

A. Submit project record documents under provisions of Section 26 05 00.

B. Accurately record location of all controls and devices. Include description of switching sequences and circuiting arrangements.

1.8 OPERATION AND MAINTENANCE DATA

A. Submit emergency, operation, and maintenance data under provisions of Section 26 05 00. Data shall also include the following:

1. Schedule for routine maintenance, inspection, and calibration of all lighting control devices and system components. Recommended schedule for inspection and recalibration of sensors.

2. Complete narrative describing intended operation and sequence for each control scenario and system component, updated to reflect all changes resulting from commissioning of systems. Narrative shall indicate recommended settings for devices where applicable.

3. Replacement part numbers for all system components.

B. Identify installed location and labeling for each luminaire controlled by automated lighting controls.

1.9 SYSTEM DESCRIPTION

A. Performance Statement: This specification section and the accompanying lighting design documents describe the minimum material quality, required features, and operational requirements of the lighting control system (LCS). These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the performance required of the system, as presented in these documents, the Contractor and system manufacturer/vendor are solely responsible for determining all equipment, wiring, and programming required for a complete and operational system.

1.10 COMMISSIONING

A. Commissioning of a system or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel, is required in cooperation with the Owner's Representative. Project closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Division 1 for detailed commissioning requirements.

B. This project will have selected building systems commissioned. The Contractor is responsible to execute commissioning. The commissioning process, equipment, and systems to be commissioned are defined in Division 1.

C. The Contractor shall notify the Architect/Engineer and Owner's Representative ten (10) working days prior to scheduled commissioning date.

D. The commissioning process requires meeting attendance. Refer to Division 1 for meeting requirements.

E. The system shall be functionally tested by a factory-authorized engineer and comply with the Sequence of Operation. All loads shall be tested live for continuity and freedom from defects, and all control wiring shall be tested for continuity and connections prior to energizing the system.

1.11 WARRANTY

A. Manufacturer shall warrant products under normal use and service to be free from defects in materials and workmanship for a period of two (2) years from date of commissioning.

B. Occupancy, vacancy, daylight sensors and controls shall have a five (5) year warranty from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LIGHTING CONTROLS

A. All items of material having a similar function (e.g., switches, dimmers, sensors, contactors, relays, etc.) shall be of the same manufacturer, unless specifically stated otherwise on drawings or elsewhere in the specifications.

B. Color of lighting controls and sensors shall match the receptacle wiring devices specified in the space.

C. The functions described in the lighting sequence of operation shall dictate the actual lighting control device required to accomplish the functions described for the space.

2.2 LIGHTING CONTROL STATION

A. **[SW]** The lighting control station shall contain the controls required by the lighting sequence of operation in a common coverplate. The controls may consist of switches, dimmers, occupancy sensors, pushbuttons, etc.

1. In spaces where the wall control station is shown in multiple locations, the sequence of operation shall be the same at all locations, unless noted otherwise.

2. The controls supplier shall prepare control station shop drawings showing arrangement of controls, dimensioned elevations, wiring diagram, and recommended backboxes. The shop drawing submittal should be identified with the lighting sequence that the station provides. Submit data sheets on the switches, dimmers, sensors, buttons, etc. contained in the control station.

2.3 DEVICE COLOR

A. All switch, lighting controls, and coverplate colors shall be the same as wiring devices, unless indicated otherwise.

2.4 COVERPLATES

A. All switches and lighting controls shall be complete with coverplates that match material and color of the wiring device coverplates in the space.

B. Where several devices are ganged together, the coverplate shall be of the ganged style for the number of devices used.

C. Install nameplate identification as indicated in Section 26 05 53.

D. Plate-securing screws shall be metal with head color matching the wall plate finish.

2.5 WALL SWITCHES

A. Refer to Electrical Symbols List for device type.

B. **[SW-1P]**: Single Pole Switch:

1. Single throw, 120/277-volt, 20-amp maintained contact. Toggle handle, side and back wired.

2. Approved Manufacturers: Hubbell HBL1221, Leviton 1221-2, Pass & Seymour PS20AC1, Cooper AH1221.

C. **[SW-1P-060]**: Spring Wound Local Timer Switch:

1. 125-volt, 20-amp rated. 0 to 60-minute off delay.

2. Approved Manufacturers: Paragon SWPD60M, Tork A560M, Mark-Time 9008.

D. **[SW-1P-ADJ]**: Local Timer Switch:

1. User adjustable timeout, 120/277-volt, 800/1200 watt rating. No minimum load requirement. Flashes lights one minute before timeout.

2. Approved Manufacturers: Watt Stopper TS-400, Hubbell Automation TD200.

E. **[SW-1P-EX]**: Explosion Proof Single Pole Switch:

1. 120/277-volt, 20-amp maintained contact. Toggle handle. Suitable for use in Class 1, Division 1 areas.

2. Wet location listed, suitable for use outdoors.

3. Approved Manufacturers: Appleton EDSC175-F2, Crouse Hinds, Killark.

F. **[SW-3W-EX]:** Explosion Proof Three Way Switch

1. 120/277-volt, 20-amp maintained contact. Toggle handle. Suitable for use in Class 1, Division 1 areas.

2. Wet location listed, suitable for use outdoors.

3. Approved Manufacturers: Appleton EDSC175-F3W, Crouse Hinds, Killark.

G. **[SW-1P-LH]**: Lighted Handle Single Pole Switch:

1. 120 volt maintained contact. Toggle handle. Light on when contact open (switch off). Side and back wired.

2. Approved Manufacturers: Hubbell HBL1221ILC, Leviton 1221-LHC, Pass & Seymour PS20AC1-CSL, Cooper 2221LTW.

H. **[SW-1P-M]**: Momentary Contact Single Pole Switch:

1. 120/277-volt, 20 amp. Three position, two circuit. Center off toggle spring return handle.

2. Approved Manufacturers: Hubbell HBL1557, Leviton 1257, Pass & Seymour 1251, Cooper 1995.

I. **[SW-1P-PL]**: Red Pilot Light Single Pole Switch:

1. 120 volt maintained contact. Toggle handle. Pilot light on when contact closed (switch on). Side and back wired.

2. Approved Manufacturers: Hubbell HBL1221PL, Leviton 1221-PLR, Pass & Seymour PS20AC1-RPL, Cooper AH1221PL.

J. **[SW-1P-WP]**: Weatherproof Single Pole Switch:

1. Single throw, 120/277-volt, 20-amp maintained contact. Toggle handle, side and back wired. Provide with weatherproof coverplate.

2. Approved Manufacturers: Hubbell1221/HBL1795, Leviton 1221-2, Taymac MM180, Pass & Seymour PS20AC1/CA1-GL, Cooper 2221.

K. **[SW-3W-WP]:** Weatherproof Three Way Switch:

1. 120/277-volt, 20-amp maintained contact. Toggle handle, side and back wired. Provide with weatherproof coverplate.

2. Approved Manufacturers: Hubbell1223/HBL1795, Leviton 1223-2, Taymac MM180, Pass & Seymour PS20AC1/CA1-GL, Cooper 2223.

L. **[SW-2P]**: Two Pole Switch:

1. Single throw, 120/277-volt, 20-amp maintained contact. Toggle handle, side and back wired.

2. Approved Manufacturers: Hubbell HBL 1222, Leviton 1222-2, Pass & Seymour PS20AC2, Cooper 2222.

M. **[SW-3W]**: Three-way Switch:

1. 120/277 volt, 20 amp. Toggle handle, side and back wired.

2. Approved Manufacturers: Hubbell 1223, Leviton 1223-2, Pass & Seymour PS20AC3, Cooper AH1223.

N. **[SW-4W]**: Four-way Switch:

1. 120/277 volt, 20 amp. Toggle handle, side and back wired.

2. Approved Manufacturers: Hubbell 1224, Leviton 1224-2, Pass & Seymour PS20AC4, Cooper AH1224.

O. **[SW-A-TPCO]**: Three Position-Center Off Switch:

1. 120/277-volt, 20-amp, 2 pole maintained contact. Toggle handle, side and back wired.

2. Approved Manufacturers: Hubbell HBL1386, Leviton 1286, Pass & Seymour 1226, Cooper 2226.

2.6 LOCAL DAYLIGHTING CONTROLS

A. **[SW-LS-PC]**: Standalone Exterior Photo Sensors:

1. Sensor shall be within a weatherproof enclosure, with design operation in temperatures of -30°F to +130°F. Sensor shall have threaded stem for box mounting, with knuckle to permit aiming of receptor after installation. Sensor shall be mounted facing north.

2. Sensor shall contain an integral switching contactor rated for 277-volt operation, with loads of up to 1,800 VA. Contacts shall be configured for zero-crossing closure to provide 100,000 cycle minimum operation.

3. Sensor shall detect changes in daylight levels to provide triggering of exterior lighting equipment based on the sequence of operation.

4. Sensor shall be field configurable at the device or via handheld wireless remote controller. Configurable settings shall include:

   a. Ambient sensitivity range of 5 to 1,500 foot-candles.
   b. Adjustable setpoint.
   c. Deadband adjustment by percentage of setpoint.
   d. Time delay of up to five minutes.

5. Sensor shall be equipped with a lens cover that can be applied for system testing during daylight conditions.

6. Approved Manufacturers: Paragon, Tork, Intermatic.

2.7 INDOOR OCCUPANCY AND VACANCY SENSORS

A. General Description: Wall- or ceiling-mounting, solid-state units with a separate power supply/relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied, with a time delay for turning lights off, adjustable over a minimum range of 1 to 30 minutes. Vacancy sensors require a manual switch operation to turn lights on and off, with a time delay for turning lights off when unoccupied.

2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.

3. Relay Unit: Dry contacts rated for 20 A ballast load at 120 and 277 VAC, for 13-amp tungsten at 120 VAC, and for 1 hp at 120 VAC. Power supply to sensor shall be 24 V dc, 150-mA, Class 2 power source as defined by NFPA 70.

4. Mounting:

   a. Sensor: Suitable for mounting in any position on a standard outlet box.

   b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure. Mount relay above accessible ceiling near entry door to room or area.

   c. Time Delay and Sensitivity Adjustments: Recessed and concealed.

5. Indicator: LED to show when motion is being detected during testing and normal operation of the sensor.

6. Bypass Switch: Override the on function in case of sensor failure.

7. Power Supply and Slave Packs: Provide as required for sensor quantity and switching scheme. Mount to standard 1/2” knockout on electrical box above accessible ceiling near entry door to room or area. Sensor power shall be from emergency circuit if emergency lighting is in the area.

8. Detection Coverage (Room): Detect occupancy anywhere in an area based on hand motion.

9. Detection Coverage (Corridor): Detect occupancy based on a half-step motion.

10. Warranty: Five (5) year warranty.

B. Dual-Technology Type: Detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on and off functions shall be selectable in the field by operating controls on unit.

1. **[SW-VS-D] or [SW-OC-D]**: 360 Degree Coverage Pattern:

   a. Frequency greater than 40 KHz. Dual sensing verifications (requires both technologies to activate), either technology maintains on status. Integrated ambient light level sensor (2 to 200 FC range), adjustable sensitivity and time delay, integrated isolated relay contact. Sensor shall control all circuits in area, unless noted otherwise. Initial settings: ambient sensor 40 FC.

   b. Approved Manufacturers: Watt Stopper DT 300 Series, Hubbell OMNI-DT2000 or ATD2000C, Greengate OAC-DT, Leviton OSC##-MOW.

2. **[SW-VS-D-W] or [SW-OC-D-W]**: Wall Mounted on Adjustable Swivel Mount:

   a. Wall or ceiling sensor with adjustable settings to allow manual on/auto off or auto on/auto off. Integrated ambient light level sensor (2 to 100 FC range).

   b. Approved Manufacturers: Watt Stopper DT-200 Series, Hubbell LODTRP, Leviton OSM12--M series.

3. **[SW-O]**: Wall Switch:

   a. Wall switch with manual on/auto off. 120/277 VAC load rating of 0-800 W for ballast, LED or tungsten. 5-, 15-, 30-minute adjustable OFF delay. Coverage of minor motion in 12’ x 15’ pattern.

   b. Approved Manufacturers: Watt Stopper DW-100 Series, Hubbell LHMTS, Leviton OSSMT series.

4. **[SW-O2]**: Wall Switch:

   a. Multi-relay wall switch with manual on/auto off for two separate loads. 120/277 VAC load relay rating of 0-800 W for ballast, LED or tungsten. 5-, 15-, 30-minute adjustable OFF delay. Coverage of minor motion in 12’ x 15’ pattern.

   b. Approved Manufacturers: Watt Stopper DW-200 Series, Hubbell LHMTD, Leviton OSSMD series.

5. Sensitivity Adjustment: Separate for each sensing technology.

6. Detection Coverage:

   a. Task Areas: Detect occupancy anywhere in an area based on hand motion.

   b. Circulation Areas: Detect occupancy anywhere in an area based upon half-step walking motion.

C. Mask sensors where necessary to prevent nuisance switching from adjacent areas.

D. PIR Type: Detect occupancy by sensing a combination of heat and movement in area of coverage.

1. **[SW-OC-P-HA]**: High Bay - Aisle Coverage Pattern:

   a. 20’ to 40’ mounting height. Minimum 1.3:1 walking motion coverage pattern to height ratio. Adjustable sensitivity and time delay, integral isolated relay contact. Sensor shall control all luminaires in area. Initial settings: Time delay 10 minutes.

   b. Approved Manufacturers: Watt Stopper HB-300 Series, Hubbell FHB 140 or HMHB series, Leviton OSFHU, Greengate OEF-P.

2. **[SW-OC-P-HB]:** High Bay - 360 Degree Coverage Pattern:

   a. 20’ to 40’ mounting height. Minimum 1.3:1 walking motion coverage pattern to height ratio. Adjustable sensitivity and time delay, integral isolated relay contact. Sensor shall control all luminaires in area.

   b. Approved Manufacturers: Watt Stopper HB-300 Series, Hubbell FHB 140 or HMHB series, Leviton OSFHU, Greengate OEF-P.

3. **[SW-O]**: Wall Switch Occupancy Sensor:

   a. Passive infrared, zero crossing circuitry, integrated ambient light sensor (10 to 150 FC range), adjustable sensitivity and time delay, no minimum load requirements, manual or auto on operation, Initial settings: 10 minutes, ambient sensor 40 FC.

   b. Approved Manufacturers: Watt Stopper PW-100 Series, Sensor Switch WSX, Hubbell LHIRS1 or AP1277, Leviton ODS15, Greengate OSW-P-0451.

4. **[SW-O2]**: Dual Wall Switch Occupancy Sensor:

   a. Passive infrared, zero crossing circuitry. Switches control two separate circuits or relays. Integrated ambient light sensor (10 to 150 FC range), adjustable sensitivity and time delay, no minimum load requirements, manual or auto on operation, Initial settings: 10 minutes, ambient sensor 40 FC.

   b. Approved Manufacturers: Watt Stopper PW-200 Series, Sensor Switch WSD-2, Hubbell LHIRD2 or AP127712, Leviton ODS, Greengate OSW-P-0451.

5. **[SW-OC-P-P]**: Ceiling Mounted - 360 Degree Coverage Pattern:

   a. Passive infrared, zero crossing circuitry, integrated ambient light sensor (4 to 190 FC Range), adjustable sensitivity and time delay, integral isolated relay contact. Sensor shall control all circuits in the area unless noted otherwise. Initial settings: ambient sensor 40 FC.

   b. Approved Manufacturers: Watt Stopper CI Series, Sensor Switch CM-9, Hubbell Automation Omni-IR, Leviton OSC Series, Greengate OMR-P Series.

6. **[SW-OC-P-P2]:** Ceiling Mounted - 100 Degree Coverage Pattern:

   a. Passive infrared, zero crossing circuitry, integrated ambient light sensor (4 to 190 FC Range), adjustable sensitivity and time delay, integral isolated relay contact. Sensor shall control all circuits in the area unless noted otherwise. Initial settings: ambient sensor 40 FC.

   b. Approved Manufacturers: Watt Stopper WPIR Series, Sensor Switch CM-9, Hubbell LOIRWV or ATD1600W.

7. **[SW-OC-P-W]:** Wall Mounted - 100 Degree Coverage Pattern:

   a. Passive infrared, zero crossing circuitry, integrated ambient light sensor (4 to 190 FC range), adjustable sensitivity and time delay, integral isolated relay contact. Sensor shall control all circuits in the area unless noted otherwise. Initial settings: Ambient sensor 40 FC.

   b. Approved Manufacturers: Watt Stopper WPIR Series, Sensor Switch CM-9, Hubbell LOIRWV or ATD1600W.

8. With daylight filter and lens to afford coverage applicable to space to be controlled.

E. Ultrasonic Type: Ceiling mounting. Detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.

1. **[SW-OC-U]**: 360 Degree 20’ x 20’ Hand Motion Coverage Pattern:

   a. Frequency greater than 32 KHz solid state, adjustable sensitivity and time delay, integral isolated 1-amp relay contact, temperature and humidity resistant receivers. Sensor shall control all circuits in area, unless noted otherwise.

   b. Approved Manufacturers: Watt Stopper WT-1100 series, Hubbell OMNI-US or ATU series, Leviton OSC series, Greengate ODC-U series.

2. **[SW-OC-U2]**: 35’ x 30’ Hand Motion Coverage Pattern:

   a. Frequency greater than 32 KHz solid state, adjustable sensitivity and time delay, integral isolated relay contact, temperature and humidity resistant receivers. Sensor shall control all circuits in area, unless noted otherwise.

   b. Approved Manufacturers: Watt Stopper WT-2200 series, Hubbell OMNI-US or ATU series, Leviton OSC series, Greengate ODC-U series.

3. **[SW-OC-U-A]**: 360 Degree Two-Sided Corridor Coverage Pattern:

   a. Frequency greater than 32 KHz solid state, adjustable sensitivity and time delay, integral isolated relay contact, temperature and humidity resistant receivers. Sensor shall control all circuits in area, unless noted otherwise.

   b. Approved Manufacturers: Watt Stopper WT-2250 Series, Hubbell OMNI-US or ATU series, Greengate ODC-U Series.

4. **[SW-OC-U-W]**: Wall Mounted:

   a. Wall switch with adjustable settings to allow manual on/auto off or auto on/auto off.

   b. Approved Manufacturers: Watt Stopper UW-100 Series, Hubbell AU1277I,

5. Crystal controlled with circuitry that causes no detection interference between adjacent sensors.

2.8 TIME SWITCH

A. **[TC-7]**: Time switch, 7-day, 2 channel, electronic, two SPDT 15-amp contacts, two separate programs with 16 setpoints available, LCD display, 12 or 24-hour format, minimum 100 hours carry-over, UL listed.

   1. Approved Manufacturers: Paragon EC72, Tork DTS 200A, Intermatic ET70215C.

B. **[TC-1]**: Astronomical time switch, 7-day, 1 channel, electronic, one SPDT 5-amp contact, LCD display, 12 or 24-hour format, minimum 100 hours carryover, UL listed.

   1. Approved Manufacturers: Paragon EC71ST, Tork DWZ100A, Intermatic ET70115C.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify field dimensions and coordinate physical size of all equipment with the architectural requirements of the spaces into which they are to be installed. Allow space for adequate ventilation and circulation of air.

C. Verify that required utilities are available, in proper location, and ready for use.

D. Beginning of installation means installer accepts existing conditions.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions and approved shop drawings.

B. All wiring shall be installed in conduit.

C. All branch load circuits shall be live tested before connecting the loads to the lighting control panel.

3.3 SUPPORT SERVICES

A. Testing:

1. All loads shall be tested live for continuity and freedom from defects, and all control wiring shall be tested for continuity and connections prior to energizing the system components.

2. Verify occupancy/vacancy and daylight sensor operation is correct after furniture and equipment is installed in each area. Make adjustments to sensor settings and time delays to allow proper operation.

3. Verify occupancy/vacancy sensors are located to provide complete coverage for the area served with no nuisance switching.

   a. Relocate sensors or provide additional sensors as necessary to provide adequate coverage.

   b. Mask occupancy sensors where necessary to prevent nuisance switching from adjacent areas.

B. Training:

1. Manufacturer shall provide competent factory-authorized technician to train Owner personnel in the operation, maintenance and programming of the lighting control system. Submit training plan with notification seven (7) days prior to proposed training dates.

3.4 SYSTEM COMMISSIONING

A. Contractors' tests shall be scheduled and documented in accordance with the commissioning requirements. Refer to Section 01 09 00, General Commissioning, for further details.

B. System verification testing is part of the commissioning process. Verification testing shall be performed by the Contractor and witnessed and documented by the Commissioning Agent. Refer to Section 01 09 00, General Commissioning, for system verification tests and commissioning requirements.

C. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner's Representative. The instruction shall be scheduled in coordination with the Owner's Representative after submission and approval of formal training plans. Refer to Section 01 09 00, General Commissioning, for Contractor training requirements.

END OF SECTION

SECTION 26 20 00

SERVICE ENTRANCE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Arrangement with Utility Company for permanent electric service
B. Underground service entrance

1.2 RELATED SECTIONS AND WORK

A. Refer to the One-Line Diagram for additional information.

1.3 QUALITY ASSURANCE

A. Utility Company: Madison Gas and Electric.

B. Install service entrance in accordance with Utility Company's rules and regulations.

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Submit Utility Company prepared drawings (if applicable).

1.5 SYSTEM DESCRIPTION

A. System Voltage: 480Y/277 volts, three phase, four-wire, 60 Hertz.

PART 2 - PRODUCTS

2.1 METERING EQUIPMENT

A. Meter: Furnished by the Utility Company.

B. Meter Base: Furnished by the Contractor, as approved by the Utility Company. (Manufacturers: Milbank, Superior, Duncan, or Anchor).

C. **[MC-1]:** Exterior Mounted Metering Cabinets: Furnished and installed by the Contractor to Utility Company's specifications. Conduit and conductors between metering cabinets and instrumentation shall be by the Contractor. Connections as required by the Utility Company.

2.2 IDENTIFICATION

A. Provide a permanent plaque or sign denoting all services, feeders, and branch circuits supplying the building or structure and the area served by each. Install plaque or sign at each service disconnecting means.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Make arrangements with Utility Company to obtain permanent electric service to the Project.

B. Primary distribution equipment and pad-mounted transformers shall be furnished and installed by the Utility Company.

C. Primary conductors shall be furnished, installed, and terminated by the Utility Company. Primary conduit shall be furnished and installed by the Contractor, as shown on the drawings, to the Utility Company's requirements.

D. Underground: Install service entrance conduits in concrete envelope from Utility Company's pad mounted transformer to meter cabinet and building service entrance equipment. Utility Company will connect service conductors to transformer secondary lugs.

E. Concrete Pad for Transformer: Furnished and installed by the Contractor to Utility Company's specifications.

END OF SECTION

SECTION 26 22 00

DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Dry type two winding transformers **[TR-#]**

1.2 REFERENCES

A. NEMA - ST 1 - Specialty Transformers

B. NEMA ST 20 - Dry Type Transformers for General Applications

C. ANSI/IEEE C57.12.01 - General Requirements for Dry Type Distribution and Power Transformers

D. ANSI/IEEE C57.12.91 - Test Code for Dry Type Distribution and Power Transformers

E. Department of Energy 10 CFR Part 431 – Energy Conservation Program for Commercial Equipment: Distribution Transformers Energy Conservation Standards; Final Rule.

F. NEMA TP 2 - Standard Test Method for Measuring the Energy Consumption of Distribution Transformers

G. NEMA TP 3 - Standard for the Labeling of Distribution Transformer Efficiency

1.3 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Include outline and support point dimensions of enclosures and accessories, unit weight, voltage, KVA, and impedance ratings and characteristics, loss data, efficiency at 35, 50, 75 and 100 percent rated load, sound level, tap configurations, insulation system type, and rated temperature rise.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products under provisions of Section 26 05 00.

B. Store in a warm, dry location with uniform temperature. Cover ventilating openings to keep out dust.

C. Handle transformers using only lifting eyes and brackets provided for that purpose. Protect units against entrance of rain, sleet, or snow if handled in inclement weather.

PART 2 - PRODUCTS

2.1 DRY TYPE TWO WINDING TRANSFORMERS

A. Dry Type Transformers: NEMA ST 20, factory-assembled, air-cooled dry type transformers; ratings as shown on the drawings. Transformers supplied under this project shall meet the US Department of Energy (DOE) 2016 Efficiency requirements or the most current DOE CFR in effect.

B. Insulation system and average winding temperature rise for rated KVA as follows:

Ratings	Class	Rise (degree C)
Less than 15	185	As shown on the drawings
15 or higher	220	As shown on the drawings

C. Case temperature shall not exceed 40°C rise above ambient at its warmest point.

D. Winding Taps, Transformers Less than 15 KVA: Two 5 percent below rated voltage, full capacity taps on primary winding.

E. Winding Taps, Transformers 15 KVA and Larger: Two (2) 2-1/2% below and two (2) 2-1/2% above rated voltage, full capacity taps on primary winding.

F. Sound Levels: Average audible sound level shall not exceed the values given below when tested to NEMA ST 20 standards:

	Average Sound Level, Decibels			
	Self-Cooled Ventilated			**Self-Cooled Sealed**
Equivalent Winding kVA Range	**K-Factor = 1 K-Factor = 4 K-Factor = 9**	**K-Factor = 13 K-Factor = 20**	**Forced Air w/ Fans Running**	
0-9	40	40	67	45
9.01-30.00	45	45	67	50
30.01-50.00	45	48	67	50
50.01-150.00	50	53	67	55
150.01-300.00	55	58	67	57
300.01-500.00	60	63	67	59
500.01-700.00	62	65	67	61
700.00-1000.00	64	67	67	63

G. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

H. Mounting: Transformers 75 KVA and less shall be suitable for wall, floor, or trapeze mounting; transformers larger than 75 KVA shall be suitable for floor or trapeze mounting.

I. Coil Conductors: Continuous windings with terminations brazed or welded.

J. Enclosure: NEMA ST 20; Type 1. Provide lifting eyes or brackets.

K. Isolate core and coil from enclosure using vibration-absorbing mounts.

L. Nameplate: NEMA TP 3; Include transformer connection data and overload capacity based on rated allowable temperature rise.

2.2 ACCESSORIES

A. Electronic Isolation Shield:

1. Provide electrostatic winding shield with separate insulated grounding connection as shown on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set transformer plumb and level.

B. Use flexible conduit, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.

3.2 FIELD QUALITY CONTROL

A. Check for damage and tight connections prior to energizing transformer.

B. Measure primary and secondary voltages and make appropriate tap adjustments. Adjustments shall be made at completion of project and at approximately 6 months following project acceptance when requested by the Owner.

END OF SECTION

SECTION 26 24 13

SWITCHBOARDS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Main and distribution switchboards**: [SB-#]**

1.2 RELATED SECTIONS AND WORK

A. Refer to the One-Line Diagram for size, rating, and configuration.

1.3 REFERENCES

A. ANSI C12 - Code for Electricity Metering

B. ANSI C39.1 - Requirements for Electrical Analog Indicating Instruments

C. ANSI C57.13 - Requirements for Instrument Transformers

D. NEMA AB 1 - Molded Case Circuit Breakers

E. NEMA KS 1 - Enclosed Switches

F. NEMA PB 2 - Dead Front Distribution Switchboards

G. NEMA PB 2.1 - Instructions for Safe Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or less

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Include front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, neutral, and ground; switchboard instrument details; instructions for handling and installation of switchboard; and electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curves of all equipment and components.

C. Submit manufacturer's instructions under provisions of Section 26 05 00.

1.5 SPARE PARTS

A. Keys: Furnish four each to the Owner.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site under provisions of Section 26 05 00.

B. Deliver in 48-inch maximum width shipping splits, unless approved otherwise by both the Contractor and Architect/Engineer, individually wrapped for protection, and mounted on shipping skids.

C. Store and protect products under provisions of Section 26 05 00.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

E. Handle in accordance with NEMA PB2.1 and manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

PART 2 - PRODUCTS

2.1 GENERAL

A. Approved Manufacturers:

1. Square D Class 2700 QED-2, QMB, I-Line, Powerstyle
2. General Electric
3. Siemens
4. Cutler Hammer

2.2 RATINGS

A. Definitions:

1. Series rated equipment shall be defined as equipment that can achieve a required UL AIC rating with an upstream device such as a main breaker or a combination of devices to meet or exceed a required UL AIC rating. All series rated equipment shall have a permanently attached nameplate indicating that device rating must be maintained. Refer to Section 26 05 53 for additional requirements.

2. Fully rated equipment shall be defined as equipment where all devices in that equipment shall carry a minimum of the AIC rating that is specified.

B. The switchboards for this project shall be fully rated.

2.3 SWITCHBOARD CONSTRUCTION AND RATINGS

A. Factory-assembled, dead front, metal-enclosed, and self-supporting switchboard assembly conforming to NEMA PB2, and complete from incoming line terminals to load-side terminations.

B. Switchboard electrical ratings and configurations as shown on the drawings.

C. Line and Load Terminations: Accessible from the front only of the switchboard, suitable for the conductor materials used.

D. Main Section Devices: Individually mounted and compartmented.

E. Distribution Section Devices: Group mounted.

F. Auxiliary Section Devices: Individually mounted and compartmented.

G. Bus Material: Aluminum with tin plating, sized in accordance with NEMA PB 2.

H. Bus Connections: Bolted, accessible from front only for maintenance. Plug-on connections may be utilized with Architect/Engineer's pre-approval by addenda.

I. Bus bars shall be fully isolated, braced for minimum ampere rms symmetrical rating as indicated on drawings.

J. The bus shall extend the full height of the distribution sections to provide space for future breakers.

K. Provide a 1 X 1/4-inch copper ground bus through the length of the switchboard.

L. Enclosure shall be NEMA PB 2; Type 1 - General-Purpose. Sections shall align at front and rear.

M. Switchboard Height: NEMA PB 2; 92 inches, excluding floor sills, lifting members and pull boxes.

N. Finish: Manufacturer's standard light gray enamel over external surfaces. Coat internal surfaces with minimum one coat corrosion-resisting paint, or plate with cadmium or zinc.

O. Pull Box: Same construction as switchboard, size as shown on the drawings. Top and sides shall be removable. Insulating, fire-resistive bottom with separate openings for each circuit to pass into switchboard.

P. Future Provisions: In addition to the spare devices shown, provide a minimum of 15 inches of fully equipped space for future devices with bussing and bus connections, suitably insulated and braced for short circuit currents. Continuous current rating as indicated on the drawings.

Q. Suitable for use as service entrance equipment.

2.4 SWITCHING, OVER-CURRENT PROTECTIVE DEVICES, AND ARC ENERGY REDUCTION

A. Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole. **Provide breaker interrupting ratings as indicated on the plans. Where necessary to meet interrupting ratings, breakers shall be provided with automatically resetting current limiting elements in each pole.**

B. Solid State Molded Case Circuit Breakers: **(All breakers identified on plans as solid-state with 2,500 ampere frame sizes and below.)** Provide molded case switch with electronic sensing, timing, and tripping circuits for fully adjustable time current characteristic settings including ground fault trip, instantaneous trip, long time trip, long time delay, short time trip, and short time delay. Trip setting shall be field programmable with a sealable clear cover. Provide stationary mounting. Ground fault sensing shall be breaker integral with circuit breaker.

C. Solid-State Insulated Case Circuit Breakers: (**All breakers identified on plans as solid state with frame sizes above 2,500 ampere.) Provide insulated case switch with two-step stored energy closing. Provide manual charging handle, and electric charging motor where indicated as electrically operated.** Provide with rating plug as required on drawings and electronic circuits for true rms current sensing, timing, and tripping for fully adjustable time current characteristics including ground fault trip, instantaneous trip, long time trip, long time delay, short time trip, and short time delay. Trip settings shall be field programmable with a sealable clear cover. Ground fault sensing shall be summation type integral to breaker. Provide stationary mounting. **Provide breaker interrupted ratings as indicated on the plans.**

D. Arc Energy Reduction:

1. Provide an arc energy reduction system to reduce the clearing time of an arc flash event. The arc energy reduction system shall be provided for overcurrent protection devices rated 1,200 amps or larger.

E. Arc Energy Reduction with Selective Coordination:

1. Provide an arc energy reduction system to reduce the clearing time of an arc flash event. The arc energy reduction system shall be provided for overcurrent protection devices rated 1,200 amps or larger.

2. The following arc energy reduction system options are acceptable:

a. Zone-selective interlocking with permanent arc energy reduction
b. Differential relaying with permanent arc energy reduction
c. Listed energy-reducing active arch flash mitigating system

2.5 INSTRUMENTS AND SENSORS

A. Current Transformers: ANSI C57.13; 5 ampere secondary, bar or window type, with single secondary winding, unless otherwise required for application, and secondary shorting device, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

B. Potential Transformers: ANSI C57.13; 120-volt single secondary, disconnecting type with integral fuse mountings, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

C. Ground Fault Sensor: Zero sequence type.

D. Ground Fault Relay: Adjustable ground fault sensitivity from 200 to 1200 amperes, time delay adjustable from 0 to 15 seconds. Provide monitor panel with lamp to indicate relay operation, TEST and RESET control switches.

E. **[DPM]:** Digital AC Power Monitor. Capable of measuring, calculating and directly displaying; Volts (L-L, L-N), Amps, KW, KWH. Monitor shall be true RMS measurement with programmable set-up parameters. All set-up parameters data shall be stored in non-volatile memory to protect from power outages.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install switchboard in locations shown on the drawings, in accordance with manufacturer's written instructions and NEMA PB 2.1.

B. Tighten accessible bus connections and mechanical fasteners after placing switchboard.

C. Install fuses in each switch.

3.2 FIELD QUALITY CONTROL

A. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.

B. Measure insulation resistance of each bus section phase to phase and phase to ground for one minute each. Test voltage shall be 1000 volts, and minimum acceptable value for insulation resistance is 2 megohms.

C. Check tightness of accessible bolted bus joints using a calibrated torque wrench. Tightness shall be in accordance with manufacturer's recommended values.

D. Physically test key interlock systems to ensure proper function.

3.3 ADJUSTING AND CLEANING

A. Adjust all operating mechanisms for free mechanical movement.

B. Touch up scratched or marred surfaces to match original finish.

C. Provide time/current trip curves for all adjustable protection devices that require setting. Also provide curves and equipment information for associated new and existing fixed devices that require coordination with new protection devices. Submit time/current curves in hard copy or electronic format.

D. Adjust trip and time delay settings to values as scheduled, or as instructed by the Architect/Engineer.

E. Where two levels of ground fault are provided, test ground fault circuit breakers to prove selective coordination in accordance with manufacturer’s directions. Provide testing documentation with Operating & Maintenance Manual submittals.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Service and distribution panelboards**: [DP-#]**
B. Lighting and appliance branch circuit panelboards**: [Panel '###']**
C. Fusible branch circuit panelboards**: [Panel '###']**
D. Load centers**: [Panel '###']**

1.2 RELATED SECTIONS AND WORK

A. Refer to the One-Line Diagram and Panel Schedules for size, rating, and configuration.

1.3 REFERENCES

A. NEMA AB 1 - Molded Case Circuit Breakers

B. NEMA FU 1 – Low voltage cartridge fuses

C. NEMA KS 1 - Enclosed Switches

D. NEMA PB 1 - Panelboards

E. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less

F. NEMA PB 1.2 - Application Guide for Ground-fault Protective Devices for Equipment

G. UL 248 – Low-Voltage Fuses

H. UL 67 - Panelboards

1.4 SUBMITTALS

A. Submit shop drawings for equipment and component devices under provisions of Section 26 05 00.

B. Include outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker and fusible switch arrangement and sizes.

C. Selective coordination study to prove that all essential electrical systems, emergency systems and legally required standby system panelboards are selectively coordinated with all supply side overcurrent protective devices.

1.5 SPARE PARTS

A. Keys: Furnish four (4) each to the Owner.

B. Fuses: Furnish 10% or a minimum of three (3) spare fuses of each type and rating installed to the Owner.

C. Fuse Pullers: Furnish one (1) fuse puller to the Owner.

PART 2 - PRODUCTS

2.1 RATINGS

A. Definitions:

1. Series rated equipment shall be defined as equipment that can achieve a required UL AIC rating with an upstream device such as a main breaker or a combination of devices to meet or exceed a required UL AIC rating. All series rated equipment shall have a permanently attached nameplate indicating that device rating must be maintained. See Section 26 05 53 for additional requirements.

2. Fully rated equipment shall be defined as equipment where all devices in that equipment shall carry a minimum of the AIC rating that is specified.

B. The panelboards for this project shall be fully rated.

2.2 MAIN AND DISTRIBUTION PANELBOARDS

A. General

1. Approved Manufacturers:

a. Square D QMB, I-Line
b. General Electric Spectra ADS
c. Siemens F2, P4
d. Cutler Hammer PRL4, PRL5

B. Panelboards: NEMA PB 1; type as shown on the drawings.

C. Enclosure: NEMA PB 1; Type 1.

D. Provide cabinet front with hinged trim on door to allow access to wiring gutters without removal of trim and flush lock. Finish in manufacturer's standard gray enamel.

E. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

F. All spaces shown on the one-line diagram shall be fully prepared spaces for future breakers.

G. Minimum Integrated Short Circuit Rating: 100,000 amperes rms symmetrical for 240-volt panelboards; 50,000 amperes rms symmetrical for 480-volt panelboards, or as shown on the drawings.

H. Fusible Switch Assemblies: NEMA KS 1; quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle. Provide interlock to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

I. Fuse Clips (Switches 600 Amperes and Smaller): Provide with Class 'R' rejection clips. Fuse Clips (601 Amperes and Larger): Designed to accommodate Class 'L' fuses.

J. Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole.

K. Molded Case Circuit Breakers with Current Limiters: Provide circuit breakers with replaceable current limiting elements, in addition to integral thermal and instantaneous magnetic trip in each pole.

L. Current Limiting Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole, coordinated with automatically resetting current limiting elements in each pole. Interrupting rating 100,000 symmetrical amperes, let-through current and energy level less than permitted for same size Class RK-5 fuse.

M. Solid State Molded Case Circuit Breakers: **(All breakers identified on plans as solid-state with 1,200 ampere frame sizes and below.)** Provide molded case switch with electronic sensing, timing, and tripping circuits for fully adjustable time current characteristic settings including ground fault trip, instantaneous trip, long time trip, long time delay, short time trip, and short time delay. Trip setting shall be field programmable with a sealable clear cover.

N. Arc Energy Reduction:

1. Provide an arc energy reduction system to reduce the clearing time of an arc flash event. The arc energy reduction system shall be provided for overcurrent protection devices rated 1,200 amps or larger.

2. Energy-Reducing Maintenance Switch: Provide an energy-reducing maintenance switch visual status indication when engaged. Install the maintenance switch at the entrance to the electrical room.

O. Suitable for use as service entrance equipment.

P. **[DPM]:** Digital AC Power Monitor. Capable of measuring, calculating and directly displaying; Volts (L-L, L-N), Amps, KW, KWH. Monitor shall be true RMS measurement with programmable set-up parameters. All set-up parameters data shall be stored in non-volatile memory to protect from power outages.

2.3 BRANCH CIRCUIT PANELBOARDS

A. General

1. Approved Manufacturers:

a. Square D NQ, NF
b. General Electric AQ, AE
c. Siemens P1
d. Cutler Hammer PRL1, PRL2

B. Lighting and Appliance Branch Circuit Panelboards: NEMA PB 1; circuit breaker type.

C. Enclosure: NEMA PB 1; Type 1.

D. Provide cabinet front with door-in-door construction, concealed hinge, and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.

E. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

F. All unlabeled circuits shown on the panelboard schedule shall be fully prepared spaces for future breakers.

G. All multiple-section panelboards shall have the same dimensional back box and cabinet front size.

H. Minimum Integrated Short Circuit Rating: As shown on the drawings.

I. Provide handle lock-on devices for all breakers serving exit sign and lighting circuits with emergency battery units. Provide handle lock-on devices and red handles for breakers serving fire alarm panels.

J. Molded Case Circuit Breakers: Bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles. Provide circuit breakers UL listed as Type SWD for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where scheduled on the drawings. Do not use tandem circuit breakers.

K. Current Limiting Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole, coordinated with automatically resetting current limiting elements in each pole. Interrupting rating 100,000 symmetrical amperes, let-through current and energy level less than permitted for same size Class RK-5 fuse.

2.4 FUSIBLE BRANCH CIRCUIT PANELBOARDS

A. General

1. Approved Manufacturers:

a. Bussmann
b. Littelfuse
c. Mersen MFCP

B. Provide cabinet front with concealed hinge and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.

C. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

D. Overcurrent protective devices shall be UL listed, with voltage, amperage, number of poles, and short-circuit current rating as shown on the panelboard schedule. Multi-pole branch circuit protection devices shall trip on an overcurrent of any pole to prevent single-phasing of the load.

E. Fuse holder shall be finger-safe with trim installed. Fuses shall only be removable when terminals are not energized.

F. All unlabeled circuits shown on the panelboard schedule shall be fully prepared spaces for future fuse units.

G. All multiple-section panelboards shall have the same dimensional backbox and cabinet front size.

H. Minimum Integrated Short Circuit Rating: As shown on the drawings.

I. Branch fuse disconnect shall have visible ON/OFF indication, blown fuse indicating lights, and permanently installed lockout means.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards plumb as indicated on the drawings in conformance with NEMA PB 1.1.

B. Height: 6 feet to handle of highest device.

C. Provide filler plates for unused spaces in panelboards.

D. Provide typed circuit directory for each branch circuit panelboard. Label each circuit with the type of load and the name and number of the area served. Revise directory to reflect circuit changes required to balance phase loads.

E. Stub five (5) empty one-inch conduits to accessible location above ceiling out of each recessed panelboard.

F. Install fuses in fusible switch assemblies.

3.2 FIELD QUALITY CONTROL

A. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 20 percent, rearrange circuits in the panelboard to balance the phase loads within 20 percent. Take care to maintain proper phasing for multi-wire branch circuits.

B. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.

END OF SECTION

SECTION 26 24 19

MOTOR CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Manual motor starters
B. Magnetic motor starters
C. Combination magnetic motor starters
D. Solid-state reduced voltage motor starters (soft starters)

1.2 RELATED SECTIONS AND WORK

A. Refer to the Disconnect and Starter Schedule and One-Line Diagram for rating and configuration.

1.3 REFERENCES

A. ANSI/UL Standard 508. Standard for Industrial Control Equipment

B. FCC Rules and Regulations, Part 15, Subpart J- Radio Frequency Interference

C. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service

D. FS W-F-870 - Fuseholders (For Plug and Enclosed Cartridge Fuses)

E. FS W-P-115 - Power Distribution Panel

F. FS W-S-865 - Switch, Box, (Enclosed), Surface-Mounted

G. IEEE Standard 519-1981 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters

H. NEMA AB 1 - Molded Case Circuit Breakers

I. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies

J. NEMA ICS 6 - Enclosures for Industrial Controls and Systems

K. NEMA KS 1 - Enclosed Switches

L. NEMA PB 1 - Panelboards

M. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or less

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Indicate on shop drawings, front and side views of motor control center enclosures with overall dimensions. Include conduit entrance locations and requirements; wiring diagrams that differentiate between manufacturer-installed and field-installed wiring; nameplate legends; size and number of bus bars per phase, neutral, and ground; electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curves of all equipment and components.

C. Provide product data on motor starters and combination motor starters, relays, pilot devices, and switching and over-current protective devices.

D. Submit manufacturer's instructions under provisions of Section 26 05 00.

1.5 SPARE PARTS

A. Keys: Furnish four (4) each to the Owner.

B. Fuses: Furnish three (3) spare fuses of each type and rating installed to the Owner.

C. Fuse Pullers: Furnish one (1) fuse puller to the Owner.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Deliver in 60-inch maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids.

C. Store and protect products under provisions of Section 26 05 00.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from fumes, dirt, water, construction debris, traffic, and physical damage.

E. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to motor control center components, enclosure, and finish.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

PART 2 - PRODUCTS

2.1 MANUAL MOTOR STARTERS

A. Manual Motor Starter: NEMA ICS 2; AC general-purpose Class A manually operated non-reversing full-voltage controller for induction motors rated in horsepower, with overload relay, and toggle operator.

B. Fractional Horsepower Manual Starter: NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, with thermal overload unit, and toggle operator.

C. Motor Starting Switch: NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, without thermal overload unit, and toggle operator.

D. Enclosure: NEMA ICS 6; Type 1.

2.2 MAGNETIC MOTOR STARTERS

A. Magnetic Motor Starters: NEMA ICS 2; AC general-purpose Class A magnetic controller for induction motors rated in horsepower.

B. Full Voltage Starting: Non-reversing type, unless otherwise indicated.

C. Coil Operating Voltage: 120 volts, 60 Hertz, obtained from integral control power transformer of sufficient capacity to operate connected pilot, indicating, and control devices, plus 100% spare capacity.

D. Size: NEMA ICS 2; size as shown on the drawings.

E. Overload Relay:

1. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.

F. Enclosure: NEMA ICS 6; Type 1.

G. Combination Motor Starters: Combine motor starters with disconnect switch in common enclosure. Provide with disconnecting means as indicated on drawings.

H. Auxiliary Contacts: NEMA ICS 2; two normally open, field convertible contacts in addition to seal-in contact.

I. Pushbuttons: NEMA ICS 2; START/STOP in front cover.

J. Indicating Lights: NEMA ICS 2; RUN: red in front cover.

K. Selector Switches: NEMA ICS 2; HAND/OFF/AUTO, in front cover.

L. Relays: NEMA ICS 2.

M. Control Power Transformers: 120 volt fused secondary, fused primary, minimum VA as scheduled:

Size 1 - 100 VA
Size 2 - 100 VA
Size 3 - 150 VA
Size 4 - 300 VA
Size 5 - 300 VA
Size 6 - 300 VA

N. Provide phase loss protection relay with contacts to de-energize the starter for each starter serving motors 5 HP or greater.

2.3 SOLID-STATE REDUCED VOLTAGE MOTOR STARTERS (SOFT STARTERS)

A. Soft Starters: ANSI/UL Standard 508. Used with NEMA Design B, AC induction motors to reduce in-rush current and mechanical shocks associated with starting and stopping motors.

B. Operation: The soft starter shall utilize a thyristor (SCR) bridge to control the starting and stopping of the motor. A microprocessor shall monitor the current and control the phasing of the SCRs. The soft starter shall provide torque control for linear acceleration without external feedback independent of motor load or motor application.

C. Torque ramp: Adjustable (by keypad) from 1 to 60 seconds.

D. Shorting Contactor: A shorting contactor shall be supplied with all soft starters rated above 40 amps. The shorting contactor shall close after the current is below 130% of motor full-load amps at the nominal voltage. The shorting contactor shall open on a stop command to allow a deceleration ramp, if applicable.

E. Status & Diagnostics: Door-mounted keypad for display of soft starter, motor, and fault statuses.

F. Motor Protection against Solid-State Component Failure: Provide an isolation contactor that opens when the motor is stopped or when the controller detects a fault condition such as a shorted thyristor.

G. Over-Current Protection Device / Power Disconnect: Integral molded case disconnect switch and in-line fuse block for RK type power fuses (up to 600 amps). Short circuit current rating shall be 65,000 AIC minimum or as indicated on drawings.

H. Overcurrent Condition: The soft starter shall be capable of supplying 300% of rated full load current for 30 seconds at maximum ambient temperature.

I. Electronic Protective Features: Thermal overload protection, phase reversal protection, stall protection, locked rotor protection, and underload protection. The display shall also indicate a starter thermal fault, phase fault, frequency fault, external fault, maximum start time exceeded, serial link fault, and internal failure.

J. Controls: The control circuitry shall be fed internally from the line supply, completely independent of the power circuit and separate from the control logic. The control circuitry shall operate at 120 VAC via an integral control power transformer.

K. Selector Switches: NEMA ICS 2; HAND/OFF/AUTO, in front cover.

L. Input: Remote control start/stop signal, and one logic input for force to freewheel, indication of external fault, force to local control, or remote overload reset.

M. Outputs: Isolation contactor status, torque ramp status, overload pre-alarm, fault alarms, and one field convertible auxiliary contact. One analog output shall be available for 4-20mA indication of motor current, torque, thermal state, or power factor.

N. Current and Horsepower Ratings: As indicated in the Starter/Disconnect Schedule on the drawings.

O. Input/Output Voltage: As indicated in the Starter/Disconnect Schedule on the drawings. The controller shall be capable of operating between -15% to +10% of nominal voltage rating.

P. Environmental Characteristics: Ambient Air Temperature: 0°C to 40°C; Maximum Relative Humidity: 93% (non-condensing); Minimum Elevation without Derating: 3300 feet.

Q. Enclosure: NEMA ICS 6; Type 12, with provisions for padlocking the door.

2.4 CONTROLLER OVER-CURRENT PROTECTION AND DISCONNECTING MEANS

A. Molded Case Thermal-Magnetic Circuit Breakers: Circuit breakers with integral thermal and instantaneous magnetic trip in each pole. NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

B. Non-fusible Switch Assemblies: Quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle. Provide interlock to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

C. Fusible Switch Assemblies: NEMA KS 1, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle. Provide interlock to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse Clips: Provide with Class' R' rejection clips. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a nationally recognized testing laboratory.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motor control equipment in accordance with manufacturer's instructions on concrete bases.

B. Install fuses in fusible switches.

C. Select and install heater elements in motor starters to match installed motor characteristics.

D. Set field-adjustable switches and circuit-breaker trip ranges.

E. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

F. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Device plates and box covers
B. Modular connectors
C. Receptacles
D. Pendant cord/connector devices
E. Cord and plug sets
F. Cord reel

1.2 QUALITY ASSURANCE

A. Provide similar devices from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the NEC Article 100, by a testing agency to Authorities Having Jurisdiction and marked for intended use.

C. Comply with the NEC.

1.3 REFERENCES

A. DSCC W-C-896F – General Specification for Electrical Power Connector
B. FS W-C-596 - Electrical Power Connector, Plug, Receptacle, and Cable Outlet
C. NEMA WD 1 – General Color Requirements for Wiring Devices
D. NEMA WD 6 – Wiring Devices – Dimensional Requirements
E. NFPA 70 - National Electrical Code (NEC)
F. UL 498 – Standard for Attachment Plugs and Receptacles
G. UL 943 – Standard for Ground Fault Circuit Interrupters

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Provide product data showing configurations, finishes, dimensions, and manufacturer's instructions.

C. Submit manufacturer occupancy sensor coverage patterns applicable to this project. For areas requiring multiple sensor devices for appropriate coverage, submit specific manufacturer approved sensor layout as an overlay directly on the project drawings, either in print or approved electronic form.

1.5 COORDINATION

A. Receptacles for Owner Furnished Equipment: Match plug configurations.

B. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 DEVICE COLOR

A. All switch, receptacle, outlet, and coverplate colors shall be gray, unless indicated otherwise.

2.2 COVERPLATES

A. All switches, receptacles, and outlets shall be complete with the following:

1. #302 stainless steel coverplates in finished spaces where walls are finished.

2. #302 stainless steel coverplates in unfinished spaces for flush boxes.

3. Galvanized steel coverplates in unfinished spaces for surface mounted boxes.

B. Where several devices are ganged together, the coverplate shall be of the ganged style for the number of devices used.

C. Install nameplate identification as indicated in Section 26 05 53.

D. Plate securing screws shall be metal with head color matching the wall plate finish.

2.3 RECEPTACLES

A. Refer to Electrical Symbols List for device type.

B. Devices that are shaded on the drawings shall be red.

C. **[REC-DUP]**: NEMA 5-20R Duplex Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type heavy duty industrial grade with impact resistant thermoplastic face and one-piece brass back strap with integral ground contacts.

2. Approved Manufacturers: Hubbell 5362, Leviton 5362, Pass & Seymour 5362A, Cooper AH5362.

D. **[REC-DUP-GFI]**: NEMA 5-20R Ground Fault Duplex Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type with test and reset buttons in impact resistant thermoplastic face.

2. Device shall perform self-test of GFCI circuitry in accordance with UL 943.

3. Approved Manufacturers: Hubbell GF20L, Leviton GFNT2, Pass & Seymour 2097, Cooper SGF20.

E. **[REC-DUP-GFI-R]**: Remote Ground Fault Device:

1. Ground fault device for remote downstream receptacles. 125-volt, 20 amp. Test and reset buttons in impact resistance thermoplastic face.

2. Approved Manufacturers: Hubbell GFBF20, Leviton 6895, Pass & Seymour 2085, Cooper VGFD20.

F. **[REC-DUP-WP]**: NEMA 5-20R Weatherproof Ground Fault Duplex Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type with test and reset buttons in impact resistant thermoplastic face. Provide NEMA 3R rated while-in-use cast aluminum cover.

2. Device shall perform self-test of GFCI circuitry in accordance with UL 943.

3. Approved Manufacturers: Hubbell GFTR20/(RW57300) WP826, Leviton GFWT2/(5977-CL) M5979, Pass & Seymour 2097TRWR/(WIUC10-C) WIUCAST1, Cooper WRSGF20/(WIU-1) WIUMV-1.

G. **[REC-DUP-XP]**: NEMA 5-20R Explosion Proof Duplex Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type, Class 1, Division 1 rated. Spring-loaded cover with gasket. Mount in cast box with threaded openings.

2. Approved Manufacturers: Appleton EFSC175, Crouse-Hinds ENRC21201, Killark UGR5-20231.

H. **[REC-USB]**: NEMA 5-20R Receptacle with USB Charger:

1. 125-volt, 20-amp, tamper resistant, 3-wire grounding type with impact resistant thermoplastic face. Type A USB charging rated at 5VDC 2.1A. Mounted in double gang backbox.

2. Approved Manufacturers: Hubbell USB20X2, Pass & Seymour TR5362USB, Cooper TR7766.

I. **[REC-ARC]**: NEMA 5-20R Receptacle with Arc Fault Circuit Interrupts

1. 125-volt, 20 amp, 3-wire grounding type hospital grade, arc fault circuit interrupter receptacle with test and reset buttons in impact resistant thermoplastic face.

2. Approved Manufacturers: Leviton AFTR2.

J. **[REC-SIM-520R]**: NEMA 5-20R Simplex Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type with impact resistant thermoplastic face.

2. Approved Manufacturers: Hubbell HBL5361, Leviton, 5361, Pass & Seymour 5361, Cooper 5361.

K. **[REC-SIM-530R]**: NEMA 5-30R Simplex Receptacle:

1. 125-volt, 30 amp, 3-wire grounding type, phenolic face.

2. Approved Manufacturers: Hubbell HBL9308, Leviton 5371, Pass & Seymour 3802, Cooper 5716N.

L. **[REC-SIM-550R]**: NEMA 5-50R Simplex Receptacle:

1. 125-volt, 50 amp, 3-wire grounding type, phenolic face.
2. Approved Manufacturers: Hubbell HBL9360, Cooper 1253.

M. **[REC-SIM-620R]**: NEMA 6-20R Simplex Receptacle:

1. 250-volt, 20 amp, 2-pole, 3-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL5461, Leviton 5461, Pass & Seymour 5871, Cooper 5461.

N. **[REC-SIM-630R]**: NEMA 6-30R Simplex Receptacle:

1. 250-volt, 30 amp, 2-pole, 3-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL9330, Leviton 5372, Pass & Seymour 3801, Cooper 5700N.

O. **[REC-SIM-650R]**: NEMA 6-50R Simplex Receptacle:

1. 250-volt, 50 amp, 2-pole, 3-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL9367, Leviton 5374, Pass & Seymour 3804, Cooper 5709N.

P. **[REC-SIM-720R]**: NEMA 7-20R Simplex Receptacle:

1. 277-volt, 20 amp, 2-pole, 3-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell, Leviton, Pass & Seymour 7621.

Q. **[REC-SIM-730R]**: NEMA 7-30R Simplex Receptacle:

1. 277-volt, 30 amp, 2-pole, 3-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL9315, Leviton 9730-A, Pass & Seymour, Cooper 5795N.

R. **[REC-SIM-750R]**: NEMA 7-50R Simplex Receptacle:

1. 277-volt, 50 amp, 2-pole, 3-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL9365, Leviton 9750-A, Pass & Seymour, Cooper.

S. **[REC-SIM-1420R]**: NEMA 14-20R Simplex Receptacle:

1. 125/250-volt, 20 amp, 3-pole, 4-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL8410, Pass & Seymour 3820, Cooper 5759.

T. **[REC-SIM-1430R]**: NEMA 14-30R Simplex Receptacle:

1. 125/250-volt, 30 amp, 3-pole, 4-wire grounding type with thermoplastic face. Flush mounted at +24 AFF.

2. Approved Manufacturers: Hubbell HBL9430A, Leviton 278, Pass & Seymour 3864, Cooper 5744N.

U. **[REC-SIM-1450R]**: NEMA 14-50R Simplex Receptacle:

1. 125/250-volt, 50 amp, 3-pole, 4-wire grounding type with thermoplastic face. Flush mounted at +4" AFF.

2. Approved Manufacturers: Hubbell HBL9450A, Leviton 279, Pass & Seymour 3894, Cooper 5754N.

V. **[REC-SIM-1460R]**: NEMA 14-60R Simplex Receptacle:

1. 125/250-volt, 60 amp, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL9460A, Leviton 9460, Pass & Seymour, Cooper 9460N.

W. **[REC-SIM-1520R]**: NEMA 15-20R Simplex Receptacle:

1. 250-volt, 20 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL8420, Leviton, Pass & Seymour, Cooper.

X. **[REC-SIM-1530R]**: NEMA 15-30R Simplex Receptacle:

1. 250-volt, 30 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL8430A, Leviton 8430, Pass & Seymour 5740, Cooper 8430N.

Y. **[REC-SIM-1550R]**: NEMA 15-50R Simplex Receptacle:

1. 250-volt, 50 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL8450A, Leviton 8450, Pass & Seymour 5750, Cooper 8450N.

Z. **[REC-SIM-1560R]**: NEMA 15-60R Simplex Receptacle:

1. 250-volt, 60 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL9460A, Pass & Seymour 5760, Cooper 8460N.

AA. **[REC-SIM-L520R]**: NEMA L5-20R Simplex Receptacle, Locking Type:

1. 125-volt, 20 amp, 2-pole, 3-wire grounding type with impact resistant thermoplastic face.

2. Approved Manufacturers: Hubbell, Leviton, Pass & Seymour L520, Cooper CWL520R.

BB. **[REC-SIM-L530R]**: NEMA L5-30R Simplex Receptacle Locking Type:

1. 125-volt, 30 amp, 2-pole, 3-wire grounding type with impact resistant thermoplastic face.

2. Approved Manufacturers: Hubbell, Leviton, Pass & Seymour L530, Cooper CWL530R.

CC. **[REC-SIM-L620R]**: NEMA L6-20R Locking Type Simplex Receptacle:

1. 250-volt, 20 amp, 2-pole, 3-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL2320, Leviton 2320, Pass & Seymour L620R, Cooper CWL620R.

DD. **[REC-SIM-L630R]**: NEMA L6-30R Locking Type Simplex Receptacle:

1. 250-volt, 30 amp, 2-pole, 3-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL2620, Leviton 2620, Pass & Seymour L630R, Cooper CWL630R.

EE. **[REC-SIM-L720R]**: NEMA L7-20R Locking Type Simplex Receptacle:

1. 277-volt, 20 amp, 2-pole, 3-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL2330, Leviton 2330, Pass & Seymour L720R, Cooper CWL720R.

FF. **[REC-SIM-L730R]**: NEMA L7-30R Locking Type Simplex Receptacle:

1. 277-volt, 30 amp, 2-pole, 3-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL2630, Leviton 2630, Pass & Seymour L730R, Cooper CWL730R.

GG. **[REC-SIM-L1420R]**: NEMA L14-20R Locking Type Simplex Receptacle:

1. 125/250-volt, 20 amp, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL 2410, Pass & Seymour L1420, Cooper CWL1420R.

HH. **[REC-SIM-L1430R]**: NEMA L14-30R Locking Type Simplex Receptacle:

1. 125/250-volt, 30 amp, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL 2710, Leviton 2710, Pass & Seymour L1430R, Cooper CWL1430R.

II. **[REC-SIM-L1520R]**: NEMA L15-20R Locking Type Simplex Receptacle:

1. 250-volt, 20 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL2420, Leviton 2420, Pass & Seymour L1520R, Cooper CWL1520R.

JJ. **[REC-SIM-L1530R]**: NEMA L15-30R Locking Type Simplex Receptacle:

1. 250-volt, 30 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL2720, Leviton 2720, Pass & Seymour L1530R, Cooper CWL1530R.

KK. **[REC-SIM-L1620R]**: NEMA L16-20R Locking Type Simplex Receptacle:

1. 480-volt, 20 amp, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL2431, Pass & Seymour L1620R, Cooper CWL1620R.

LL. **[REC-SIM-L1630R]**: NEMA L16-30R Locking Type Simplex Receptacle:

1. 480-volt, 30 amp, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL2730, Leviton 2730, Pass & Seymour L1630R, Cooper CWL1630R.

MM. **[REC-SIM-L2120R]**: NEMA L21-20R Locking Type Simplex Receptacle:

1. 120/208Y 3 phase 20-amp 5 wire grounding type.

2. Approved Manufacturers: Hubbell HBL2510, Cooper CWL2120R, Pass & Seymour L2120R.

NN. **[REC-SIM-L2130R]**: NEMA L21-30R Locking Type Simplex Receptacle:

1. 120/208Y 3 phase 30-amp 5 wire grounding type.

2. Approved Manufacturers: Hubbell HBL2750, Cooper CWL2130R, Pass & Seymour L2130R.

OO. **[REC-SIM-XP]**: NEMA 5-20R Explosion Proof Simplex Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type, Class 1, Division 1, Group C rated. Factory sealed, dead end.

2. Approved Manufacturers: Appleton CPE1-2375, Crouse-Hinds CPS152201, Killark KRS-215-220.

PP. **[REC-TAMP]**: NEMA 5-20R Tamper Resistant Duplex Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type with impact resistant thermoplastic face.

2. Approved Manufacturers: Hubbell BR20TR, Leviton TBR20, Pass & Seymour TR5362, Cooper TRBR20.

3. Provide decorative style duplex tamper resistant receptacles in public spaces where walls are finished.

4. Approved Manufacturers: (Decorative), Hubbell DR20TR, Leviton TDR20, Pass & Seymour TR2635.

QQ. **[REC-TAMP-GFI]**: NEMA 5-20R GFI Tamper Resistant Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type tamper-resistant with test and reset buttons in impact resistant thermoplastic face.

2. Device shall perform self-test of GFCI circuitry in accordance with UL 943.

3. Approved Manufacturers: Hubbell GFTR20, Cooper TRSGF20, Pass & Seymour 2097TR, Leviton GFTR2.

RR. **[REC-TAMP-QUAD]**: NEMA 5-20R Double Duplex Tamper Resistant Receptacle:

1. Consists of two duplex tamper resistant receptacles, double gang box, plaster ring and faceplate.

2. Approved Manufacturers: Refer to Tamper Resistant Receptacle above.

SS. **[REC-DUP-O]**: NEMA 5-20R Plug Load Controlled Duplex Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type with impact resistant thermoplastic face and steel back strap. Bottom half of duplex shall be split circuit wired and controlled by remote relay. Controlled receptacle shall have permanent NEMA approved and NEC 2014 compliant marking on face of device.

2. Approved Manufacturers: Pass & Seymour 5362H, Leviton 5362-1P, Hubbell, Cooper.

TT. **[REC-QUAD-O]**: NEMA 5-20R Plug Load Controlled Duplex Receptacle:

1. Consists of two duplex tamper resistant receptacles, double gang box, plaster ring and faceplate.

2. Approved Manufacturers: Refer to Plug Load Controlled Duplex Receptacles above.

UU. **[REC-QUAD]:** NEMA 5-20R Double Duplex Receptacle:

1. Consists of two duplex receptacles, double gang box, plaster ring and faceplate.

2. Approved manufacturers: Refer to Duplex Receptacle above.

VV. **[REC-QUAD-GFI]**: NEMA 5-20R Double Duplex GFI Receptacle:

1. Consists of two duplex GFI receptacles, double gang box, plaster ring and faceplate.

2. Approved Manufacturers: Refer to Duplex GFI Receptacle above.

WW. **[REC-QUAD-USB]**: NEMA 5-20R Double Duplex USB Receptacle:

1. Consists of two duplex USB receptacles, double gang box, plaster ring and faceplate.

2. Approved Manufacturers: Refer to USB Receptacle above.

XX. **[REC-QUAD-WP]**: NEMA 5-20R Weatherproof Ground Fault Quad Receptacle:

1. Consists of two duplex, GFI receptacles. Double gang box. Provide NEMA 3R rated while-in-use cast aluminum cover.

2. Approved Manufacturers:

a. Receptacle: Refer to GFCI Receptacle above.

b. Cover: Intermatic WP1030MXD, Pass & Seymour WIUCAST2, Thomas & Betts Red Dot 2CKU.

YY. **[REC-XR#]**: 600-volt, 60 amp, 3-pole, 4-wire Locking Type Simplex Receptacle for X-ray Isolated Power Equipment:

1. Black nylon or polycarbonate face. Cast aluminum surface mounted box, 45° angle adapter, weather protective lift cover on receptacle.

2. Approved Manufacturers: Hubbell HBL26410-RECP/HBL26401-BOX/HBL26404-ADAPTER, Pass & Seymour 26420/26401/26404, Cooper 26420/26401/26404.

ZZ. Back wired devices shall be complete with eight holes that are screw activated with metal clamps for connection to #12 or #10 copper conductors.

AAA. Side wired devices shall have four binding screws that are undercut for positive wire retention.

BBB. Ground fault circuit interrupter (GFCI) receptacles shall comply with UL 943 requiring increased surge immunity, improved corrosion resistance, improved resistance to false tripping and diagnostic indication for miswiring if the line and load conductors are reversed during installation.

CCC. Isolated ground receptacles shall have the equipment ground contacts connected only to the green grounding screw terminal of the device with inherent electrical isolation from the mounting strap.

DDD. Integral surge suppression receptacles with integral surge suppression shall comply with the following:

1. Category A3 listed.

2. Line to ground, line to neutral, and neutral to ground modes.

3. Metal-oxide varistors with a nominal clamp level rating of 500 volts and minimum single transient pulse energy dissipation of 210 joules per mode.

4. Status indication: Light visible in the face of the device and audible alarm to indicate device is no longer active or in service.

5. Distinctive symbol on device face to denote SPD-type device.

6. Device shall be blue with stainless coverplate.

7. NEMA 5-20R duplex receptacle, 125-volt, 20 amp, 3-wire grounding type heavy duty industrial grade with impact resistant thermoplastic face and one-piece brass back strap.

   a. Approved Manufacturers: Hubbell HBL5362SA, Leviton, Pass & Seymour, Cooper.

EEE. Hazardous (Classified) location receptacles shall comply with NEMA FB 11.

2.4 PENDANT CORD/CONNECTOR DEVICES

A. Description: Matching, locking type plug and receptacle body connector, NEMA WD 6, Configurations L5-20P and L5-20R, heavy-duty grade or refer to Details as shown on drawings.

1. Body: Nylon with screw-open cable gripping jaws and provisions for attaching external cable grip.

B. External Cable Grip: Woven wire mesh type made of high strength galvanized steel wire stand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.5 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded copper conductors, with Type SOW-A jacket; with green insulated grounding conductor and equipment rating ampacity plus a minimum of 30 percent.

2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection, FS/UL listed.

2.6 CORD REELS

A. **[CR-1]**: 50’ 3#12 AWG type ‘SOW-A’ cord with adjustable ball stop. 120 volt, NEMA 5-20R, simplex receptacle connector, rated 16 amps continuous.

1. Approved Manufacturers:

   a. Daniel Woodhead 92433, 9521 w/ Hubbell 5369CY
   b. Appleton RL153L
   c. Hubbell HBL HBL45123C20

B. **[CR-2]**: 25' 3#16 AWG type 'SJOW-A' cord with adjustable ball stop. Two 120-volt NEMA 5-15R receptacles mounted in cast outlet box, rated 10 amps.

1. Approved Manufacturers:

a. Daniel Woodhead 925
b. Appleton RL2510
c. Hubbell HBLC25163C

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install light switches, dimmers, and convenience receptacles at elevations indicated in the General Installation Notes on the contract drawings.

B. Install specific-use receptacles at heights shown on the contract drawings. Install devices level, plumb, and square with building lines. Coordinate installation of adjacent devices of separate systems with common mounting heights, including lighting, power, systems, technology, and temperature control device rough-ins.

C. Drill opening for poke-through fitting installation in accordance with manufacturer's instructions. This Contractor is responsible for taking any measures required to ensure no conduits or other services are damaged. This may include X-ray or similar non-destructive means.

D. Install receptacles vertically with ground slot up or where indicated on the drawings, horizontally with ground slot to the left.

E. Install decorative plates on switch, receptacle, and blank outlets in finished areas, using jumbo size plates for outlets installed in masonry walls.

F. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.

G. Install devices and wall plates flush and level.

H. Contractor to verify that wall dimmer ratings are achieved where a ganged installation is used.

I. Install nameplate identification to receptacle cover plates indicated. Identification shall identify panel name and circuit number. Refer to Specification Section 26 05 53 - Electrical Identification.

J. Identify locations of power packs, control units, and relays above ceiling on record drawing.

K. Test receptacles for proper polarity, ground continuity and compliance with requirements.

L. Healthcare devices shall be tested in accordance with NFPA 99 6.3.3 for grounding, voltage, and impedance measurements.

END OF SECTION

SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fuses
B. Spare Fuse Cabinet

1.2 REFERENCES

A. UL 198C - High-Interrupting Capacity Fuses; Current Limiting Types

B. UL 198E - Class R Fuses

C. FS W-F-870 - Fuseholders (For Plug and Enclosed Cartridge Fuses)

D. NEMA FU 1 - Low Voltage Cartridge Fuses

E. NFPA 70 – National Electrical Code

1.3 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

1.4 EXTRA MATERIALS

A. Provide two fuse pullers.

B. Provide three of each size and type of fuse installed.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40°F (5°C) or more than 100°F (38°C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS – FUSES

A. Cooper Bussman
B. Eagle Electric Mfg. Co.; Cooper Industries
C. Mersen
D. Tracor; Littelfuse Subsidiary

2.2 FUSES

A. Dimensions and Performance: NEMA FU 1, Class as specified or indicated.

B. Voltage: Provide fuses with voltage rating suitable for circuit phase-to-phase voltage.

C. Fuses with ratings larger than 600 amperes: Class L (time delay), unless otherwise noted on the drawings.

D. Fuses with ratings larger than 200 amperes but equal to or less than 600 amperes: Class RK-1 (time delay), unless otherwise noted on the drawings.

E. Fuses with ratings less than or equal to 200 amperes (not including control transformer fuses): Class RK-5, unless otherwise noted on the drawings.

F. Control transformer fuses: Class CC (time delay).

G. Fuses for packaged equipment: Size and type as recommended by equipment manufacturer.

2.3 SPARE FUSE CABINET

A. Cabinet: Wall-mounted, 0.05-inch- (1.27-mm-) thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
4. Fuse Pullers: For each size of fuse.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fuses where indicated on the drawings and specifications.

B. Install fuses in accordance with manufacturer's instruction.

C. Install fuses in packaged equipment as required by equipment manufacturer.

D. Install fuse with label oriented such that manufacturer, type, and size are easily read.

E. Install spare fuse cabinet in the Main Electrical Room.

END OF SECTION

SECTION 26 28 16

DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fusible switches
B. Non-fusible switches
C. Molded case circuit switches
D. Molded case switches
E. Motor disconnect switch
F. Mechanically interlocked disconnect
G. Enclosures

1.2 RELATED SECTIONS AND WORK

A. Refer to the Disconnect and Starter Schedule for rating and configuration.

1.3 REFERENCES

A. NEMA KS 1 - Enclosed Switches

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Product Data: For each type of enclosed switch, circuit breaker, accessory and component indicated, include dimensions, weights, and manufacturer's technical data on features, performance, and ratings.

C. Electrical Characteristics: For each type of enclosed switch, enclosure types, current and voltage ratings, short-circuit current ratings, UL listing for series rating of installed devices, features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.5 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE AND NON-FUSIBLE SWITCHES

A. **[FDS-#]:** Fusible Switch Assemblies: NEMA KS 1; Type heavy duty, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse Clips: Class 'R' fuse clips only, unless indicated otherwise on the drawings.

B. **[DS-#]:** Non-fusible Switch Assemblies: NEMA KS 1; Type heavy duty, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

C. Enclosures: Type as indicated on the disconnect schedule.

D. Accessories: As indicated on the disconnect schedule.

2.2 MOLDED CASE CIRCUIT BREAKERS AND SWITCHES

A. **[CB-#]:** Molded Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip settings.

3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:

a. Instantaneous trip.
b. Long- and short-time pickup levels.
c. Long- and short-time adjustments.
d. Ground-fault pickup level, time delay, and I^2t responses.

4. Current Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.

B. **[CB-#]:** Molded Case Switches: Molded case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Accessories: As indicated on the disconnect schedule.

2.3 MOTOR DISCONNECT SWITCH

A. **[DS-#]:** Rotary Switch Assemblies: Rated for making and breaking loads, rotary type enclosed switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

B. Enclosures: Type as indicated on the Disconnect Schedule.

C. Ground lug connection provided in enclosure.

D. Accessories: As indicated on the Disconnect Schedule.

E. Listed UL 508 suitable for motor control.

2.4 MECHANICALLY INTERLOCKED DISCONNECT

A. **[DSS-#]:** Switch and Plug Assemblies: Rated for making and breaking loads, enclosed switch with externally operable interlock to prevent disconnecting receptacle with switch in ON position or inserting receptacle in ON position. Padlock lockable provision to meet OSHA lockout/tagout regulations.

B. Enclosures: Type as indicated on the Disconnect Schedule.

C. Ground lug connection provided in enclosure.

D. Accessories: Matching male pin and sleeve plug, two auxiliary/pilot contacts.

E. Listed UL 2682 suitable for motor disconnect.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install disconnect switches where indicated on the drawings.

B. Install fuses in fusible disconnect switches.

C. Provide adhesive label on inside door of each switch indicating UL fuse class and size for replacement.

3.2 ADJUSTING

A. Set field-adjustable circuit breaker trip ranges.

END OF SECTION

SECTION 26 28 21

CONTACTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. General-purpose contactors
B. Lighting contactors
C. Enclosures

1.2 RELATED SECTIONS AND WORK

A. Refer to Lighting Contactor Schedule.

1.3 REFERENCES

A. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems

B. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies

C. UL 508 - Industrial Control Equipment

1.4 SUBMITTALS

A. Submit shop drawings under provisions of Section 26 05 00.

B. Include outline drawings with dimensions, and equipment ratings for voltage, capacity, and poles.

C. Submit manufacturer's instructions under provisions of Section 26 05 00.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Schneider Electric
B. Eaton Corporation
C. G.E.
D. ASCO

2.2 [C-#]: GENERAL-PURPOSE CONTACTORS

A. Contactors: NEMA ICS 2 and UL 508; electrically held, 2-wire control.

B. Coil Operating Voltage: 120 volts, 60 Hertz.

C. Size: NEMA ICS 2; size as indicated on the drawings.

D. Contacts: 600 volts, 60 Hertz.

E. Enclosure: ANSI/NEMA ICS 6; Type 1.

F. Provide solderless pressure wire terminals.

2.3 [LC-#]: LIGHTING CONTACTORS

A. Contactors: NEMA ICS 2 and UL 508; electrically held, 2-wire control.

B. Coil Operating Voltage: 120 volts, 60 Hertz.

C. Contacts: As indicated on the drawings.

D. Enclosure: ANSI/NEMA ICS 6; Type 1.

E. Provide solderless pressure wire terminals.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction boxes: and equipment enclosures.

E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

END OF SECTION

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Air terminals and interconnecting conductors
B. Grounding and bonding for lightning protection

1.2 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. Section 26 05 26 - Grounding and Bonding
B. Section 26 43 00 - Surge Protection Devices

1.3 REFERENCES

A. ANSI/NFPA 780 - Lightning Protection Code
B. ANSI/UL 96 - Lightning Protection Components
C. UL 96A - Installation Requirements for Lightning Protection Systems

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Shop drawings shall indicate layout of air terminals, grounding electrodes, and bonding connections to structure, ground grid, and other metal objects. Include terminal, electrode, and conductor sizes, and connection and termination details. Include indications for use of raceway and type, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

C. Product data shall show dimensions and materials of each component, and include indication of listing in accordance with ANSI/UL 96 or a nationally recognized testing laboratory.

D. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL or LPI.

E. Submit manufacturer's installation instructions under provisions of Section 26 05 00.

F. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.

G. Field inspection reports indicating compliance with specified requirements.

1.5 SYSTEM DESCRIPTION

A. Lightning Protection System: System protecting all buildings and landfill gas conditioning equipment on site, consisting of air terminals on roofs, roof-mounted mechanical equipment, chimneys and stacks, parapets, bonding of structure, gas conditioning equipment, and other metal objects; grounding electrodes; and interconnecting conductors. Class I materials shall be used for systems on structures not exceeding 75 feet in height. Class II materials shall be used for systems on structures exceeding 75 feet in height above grade.

B. Performance Statement: This specification and the accompanying roof plans describe the minimum material quality, required features, and operational requirements of the system. These documents do not convey every air terminal, conductor, and connection that must be made. Based on the equipment described and the performance required of the system, as presented in these documents, the Vendor and the Contractor are solely responsible for determining all equipment and wiring required for a complete and operational system.

1.6 PROJECT RECORD DOCUMENTS

A. Submit project record documents under provisions of Section 26 05 00.

B. Accurately record actual locations of air terminals, grounding electrodes, bonding connections, and routing of system conductors.

C. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in lightning protection equipment with minimum three (3) years documented experience or who is listed by a nationally recognized testing laboratory.

B. Installer: Authorized installer of manufacturer with minimum three (3) years documented experience.

C. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.8 PRE-INSTALLATION CONFERENCE

A. Convene a pre-installation conference prior to commencing work of this Section.

1.9 SEQUENCING AND SCHEDULING

A. Coordinate work under provisions of Section 26 05 00.

B. Coordinate the work of this Section with exterior and interior finish installations. Coordinate painting of exposed conduits to match building finish with Architect.

C. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

D. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Heary Brothers Lightning Protection Co., Inc.
B. Thompson Lightning Protection.
C. Harger Lightning Protection.
D. Robbins Lighting, Inc.
E. Erico International Corporation.
F. Burndy Thermoweld
G. VFC Lightning Protection

2.2 MATERIALS

A. All materials shall be copper and/or copper-bronze. In locations where the system components are mounted on aluminum surfaces, aluminum materials shall be used to avoid electrolytic corrosion of dissimilar metals.

B. Components: In accordance with ANSI/UL 96 or nationally recognized testing laboratory.

C. Air Terminals: Solid, unless otherwise indicated. Provide air terminals with safety 3/4" sphere tip. Provide swivel adapters to plumb air terminals when mounting on sloping surfaces.

D. Air Terminal for Chimney: Lead-coated copper.

E. Grounding Rods: Copper clad steel.

F. Ground Plate: 18"x18"x0.032" Copper ground plate.

G. Connectors and Splicers: Bronze, unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify that field measurements are as shown on the shop drawings.

C. Beginning of installation means installer accepts existing conditions.

3.2 PROTECTION OF SURROUNDING ELEMENTS

A. Protect elements surrounding work of this Section from damage or disfiguration.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with ANSI/NFPA 780, UL 96A, and LPI-175.

C. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops.

D. Conceal the following conductors:

1. System conductors.
2. Down conductors.
3. Interior conductors.
4. Conductors within normal view from exterior locations at grade within 200 feet (60 m) of building.
5. Notify Architect/Engineer at least 48 hours in advance of inspection before concealing lightning protection components.

E. Bond extremities of metal bodies exceeding 60 feet (18 m) in vertical length to structural steel members.

F. Provide a ground ring electrode that meets or exceeds minimum requirements in NFPA 780.

1. Bond ground terminals to ground ring electrode.
2. Bond grounded metal bodies on building within 12 feet (3.6 m) of ground to ground ring electrode.
3. Bond grounded metal bodies on building within 12 feet (3.6 m) of roof to interconnecting loop at eave level or above.

G. Structures exceeding 60 feet in height: Bond lightning protection components with intermediate-level interconnection loop conductors to down conductors and other grounded media at maximum 60-foot (18-m) intervals.

3.4 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

C. Bi-metal transition fittings shall be used when changing between aluminum and copper conductors.

3.5 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 26 05 00.

B. Obtain the services of Underwriters' Laboratories, Inc. to provide inspection and certification of the lightning protection system under provisions of UL 96A to obtain a UL Master Label for system.

C. Install UL Master Label and attach to building at location directed by the Owner.

D. Provide an inspection by an inspector certified by LPI to obtain an LPI certification.

END OF SECTION

SECTION 26 43 00

SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes materials and installation requirements for low voltage surge protection devices (SPD) for the protection of all AC electrical circuits. SPD equipment to be installed at designated service entrance equipment, distribution panels, and electronic equipment.

1.2 QUALITY ASSURANCE

A. The specified unit shall be designed, manufactured, tested and installed in compliance with the above references. The unit shall be "Listed by Underwriters Laboratories" to UL 1449.

B. Each unit shall be designed and manufactured by a qualified manufacturer of power conditioning equipment. The qualified manufacturer must have been engaged in the design and manufacturer of such products for a minimum of five years.

1.3 REFERENCES

A. ANSI/IEEE C62.33 – IEEE Guide on Testing of MOV components

B. ANSI/IEEE C62.35 – IEEE Guide on Testing of SAD components

C. ANSI/IEEE C62.41 - IEEE Recommended Practice on Surge Voltage in Low Voltage AC Power Circuits

D. ANSI/IEEE C62.45 - IEEE Guide on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits

E. ANSI/UL 1449 Third Edition (Version 3.0) - UL Standard for Safety for Surge Protective Devices

F. CBEMA – Computer Business Equipment Manufacturers Association

G. IEC 664 – International Engineering Consortium, Standard for Clamping Voltage

H. National Electrical Code 285 - Surge Protection Devices

I. NFPA 70 - National Electrical Code

J. UL 67 – Listed for Internal Panelboard Transient Voltage Surge Suppressors

K. UL 96A – Devices listed as approved for secondary surge arrestors (VZCA)

L. UL 248-1 - Fusing

M. UL 1283 – Electromagnetic Interference Filters, Fifth Edition

1.4 SUBMITTALS

A. Shop Drawings: Should include device dimensions, mounting requirements including wire size and over-current protection device rating, nameplate nomenclature, electrical ratings, short circuit current rating, and test results as indicated below under "Testing, Warranty and Life Expectancy" as provided by an independent test lab or a UL certified test lab for the category(ies) of suppression device(s) specified using the appropriate IEEE test wave. Product data sheets with installation instructions for each size and type of device are required. Shop drawings submitted without the testing data as required by section this section will be rejected.

B. Fuse information: Provide fuse information if required for operation. Include size, manufacturer, time-current chart responses to UL 1449 testing requirements, maximum surge protection capability per mode and phase as limited by the fuse, and verification of repetitive surge protection device operation without system degeneration greater than 10%.

1.5 SPARE PARTS

A. Fuses: Furnish to the Owner 3 spare fuses of each type and rating installed.

1.6 TESTING, WARRANTY AND LIFE EXPECTANCY

A. Manufacturer must provide independent testing on repetitive capability and maximum surge current rating of service entrance suppressor units. This shall be performed at a nationally recognized lab not affiliated with the manufacturer.

1. Single pulse surge current capacity: Single pulse surge current tested in a mode at rated surge currents.

2. Single pulse surge current capacity test: An initial UL 1449 defined 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit's suppression voltage (VPR).

3. A single 8 x 20µs waveform pulse of maximum rated surge current per mode shall then be applied. To complete the test, another UL 1449 surge shall be applied to verify the unit's survival. Survival is achieved if the suppression voltage measured from the two UL1449 surges does not vary by more than 10%.

B. Minimum Repetitive Surge Current Capacity:

1. Service entrance suppressor units should be tested repetitively at an independent lab to verify repetitive capacity.

2. Minimum Repetitive Surge Current Capacity Test:

a. An initial UL 1449 surge defined as 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit's suppression voltage.

b. A repetitive number of ANSI/IEEE C62.41.2-2002 (Category C3) surges, defined as a 1.2 x 50µs 10kV or 20kV open circuit voltage waveform and an 8 x 20µs 10,000A short circuit current waveform, shall then be applied at one-minute intervals.

c. To complete the test, another UL 1449 surge shall be applied to verify the unit's survival.

3. Survival is achieved if the suppression voltage (VPR) does not vary by more than 10%.

4. Proof of such testing shall be the test log generated by the surge generator.

C. Provide UL 1449 classification white sheet pages indicating the VPR (voltage protection rating) for each SPD unit submitted for this product using the 6kV/3kA combination wave surge.

D. Warranty: Ten (10) years. Includes workmanship, installation and programming.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. General: The unit shall provide transient voltage suppression, surge current diversion and high-frequency noise attenuation, when connected in parallel to the facilities distribution system. The unit MCOV shall not be less than 115% of the nominal system voltage. Operating frequency shall be for a 60 Hz system. The unit shall provide protection in all normal modes for "wye" and "delta" systems. The short circuit current rating shall be the larger of the listed value on the drawings or as required by the equipment protected.

2.2 RATINGS

A. **[SPD-#]:** Service Entrance Suppressors:

1. For 277/480-volt, 3 phase, 4 wire, type 2, category C3 unit.

a. Surge current capacity: 100,000/200,000 amps per protection mode/phase

b. Nominal Discharge Current: 20 kA.

c. Mounting: Refer to the drawings.

d. Voltage Protection Rating: Refer to requirements below.

e. Components: Minimum component size of 20mm metal oxide varistors (MOV).

f. Disconnect: Surge-rated disconnect with 200,000 SCCR.

2. Approved Manufacturers:

a. Square D Surelogic EMA Series
b. Siemens TPS3 Series

c. Cutler Hammer SPD Series
d. Current Technology Current Guard Plus
e. Emerson Network Power 560 Series
f. LEA International LSS Series

B. **[SPD-#]:** Secondary Distribution Suppressors:

1. For 277/480-volt, 3 phase, 4 wire, type 2, category B3/C1 unit.

a. Surge current capacity: 100,000/200,000 amps per protection mode/phase

b. Nominal Discharge Current (I_N): 20 kA.

c. Mounting: Refer to the drawings.

d. Voltage Protection Rating: Refer to requirements below.

e. Components: Minimum component size of 20mm metal oxide varistors (MOV).

2. Approved Manufacturers:

a. Square D Surgelogic EMA Series
b. Siemens/APT TPS3 Series
c. Cutler Hammer SPD Series
d. Current Technology Current Guard Plus
e. Emerson Network Power 510 Series
f. LEA International CFS Series

C. Voltage Protection Rating:

1. Protection modes and UL 1449 voltage protection rating for surge suppression units per each mode (L-N, L-L, L-G, and N-G as appropriate).

a. 277/480 Volt, 3 phase, 4 wire.1200 Volt L-N, L-G, N-G and 1800 Volt L-L
b. 480 Volt, 3 phase, 3 wire. 2000 Volt L-G, L-L
c. 120/208 Volt, 3 phase, 4 wire. 700 Volt L-N, N-G, 800 Volt L-G and 1200 Volt L-L

D. Critical Load Protection – Fixed Equipment:

1. For 120-volt, 1 phase, 3 wire, type 3, category A3 unit.

a. Surge current capacity (I_N): 15,000/30,000 amps per protection mode/phase

b. Mounting: External, NEMA 12 enclosure

c. Components: Nonmodular units composed of 20mm Metal Oxide Varistors (MOV). Series inductors, SAD, or selenium cells may be used in addition to MOVs.

d. Protection modes and UL 1449 clamping voltage: 475 Volt L-N, L-G, and N-G.

E. EMI/RFI Noise Rejection or Filtering:

1. Each unit shall include a UL1283 first order, high-frequency filter for noise filtering between 10 KHz and 100 MHz.

F. Indication:

1. Each unit shall include solid-state indicators with externally mounted LED visual status indicators that indicate on-line status of each protection mode of the unit.

2. Each unit shall include an audible alarm with silencing switch to indicate when protection has failed.

3. Provide each service entrance secondary distribution and critical load type unit(s) with a transient counter.

4. Each unit shall contain form "C" contacts for remote indication of an alarm status.

G. Fuses:

1. Use fuses recommended by the manufacturer to satisfy repetitive UL 1449 operation of the surge suppression unit.

2. Fuses shall be rated 200, 000 AIC minimum interrupting capacity.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine equipment for size and type of surge protection device to be used to ensure physical compatibility.

B. Inspect surge protection device for any signs of physical damage due to shipping or handling before installing surge protection device.

3.2 INSTALLATION

A. Mounting Location:

1. The unit shall be installed as close as practical to the panel and transformer secondary lugs in accordance with applicable national/Local Electrical Codes and the manufacturer's recommended installation instructions. Connect the unit to the transformer or switchboard or panel using a conduit nipple. Flush mount the unit in the front of the switchboard. Mount unit directly across from the breaker or disconnect serving it.

2. If internal surge protection device is specified, device shall be installed in a barrier compartment isolated from other components.

B. Connections:

1. Contractor shall provide wire and circuit breakers sized per the approved manufacturer's requirements. Maximum lead length from protected bus to surge protection device shall be per manufacturer's requirements, but no greater than 5'-0".

2. The surge protection unit shall be isolatable from the electrical distribution system via 3 pole circuit breaker mounted in the switchboard/panelboard. Single phase 120-volt units shall be hardwired without a disconnecting means.

3. Neutral and ground shall not be bonded together at secondary panelboard locations.

C. Additional Locations: Critical Load Protection – Fixed Equipment (120 Vac):

1. Install an A3 hard-wired or plug-in surge protection device between each of the following equipment items and its power supply conductors.

   a. Phone switch
   b. Intercom master
   c. Building management system master
   d. Security system master
   e. Telephone switch
   f. TV head

D. General:

1. Check unit for proper operation of protection and indication under start-up.

2. Check unit to ensure all MOVs for each mode of protection are operational. Verify integral fuse links are operational and have not melted.

3. Surge suppression devices shall not be installed ahead of the main service disconnect(s).

4. Install fuses in all fuse holders and fused disconnects internal to the surge protection unit. Use fuses recommended by the manufacturer to satisfy repetitive UL 1449 operation of the surge suppression unit. External fusing of the surge protection device is not allowed.

5. Coordinate location of surge protection device to allow adequate clearances for maintenance.

6. Manufacturer service phone number shall be posted on the front of the surge protection device.

END OF SECTION

SECTION 26 51 00

LIGHTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Interior luminaires and accessories
B. Exterior luminaires and accessories
C. Lamps
D. Ballasts
E. Poles

1.2 REFERENCES

A. ANSI C78.377-2008 – Specifications for the Chromaticity of Solid State Lighting Products

B. ANSI C82.4 - High-Intensity Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)

C. ANSI C82.6 - Ballasts for HID Lamps - Method Measurement

D. ANSI C82.11 - High Frequency Fluorescent Lamp Ballasts

E. ANSI C82.77-2002 – Standard for Harmonic Emission Limits and Related Power Quality Requirements for Lighting Equipment

F. IEEE C2 - National Electrical Safety Code

G. NEMA LE 2 - H-I-D Lighting System Noise Criterion (LS-NC) Ratings

H. UL 935 – Standard for Fluorescent Lamp Ballasts

1.3 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Submit product data sheets for luminaires, lamps, ballasts, drivers and poles. Include complete product model number with all options as specified. Submittal shall be arranged with fixtures listed in ascending order, and with each luminaire's associated lamp, ballast, driver, or pole information following luminaire's product data. Failure to organize submittal in this manner will result in the submittal being rejected.

C. Submit lens product data, dimensions and weights if not included in product data sheet submittal.

D. Include outline drawings, support points, weights, and accessory information for each luminaire type.

E. Submit utility rebate forms, where offered at project location, with rebate items completed.

F. LED luminaire submittals shall include photometric report per IESNA LM-79-08 for the latest generation system being furnished, including independent testing laboratory name, report number, date, luminaire model number, input wattage, luminaire, and light source specifications. Manufacturer origin of LED chipset and driver shall be submitted.

G. For all LED luminaires specified as dimmer controlled, submit dimmer device data that is approved by manufacturer of submitted luminaire and that Contractor proposes to furnish and install. Contractor is responsible for verifying that installed dimming controls are compatible with and approved by the luminaire manufacturer.

1.4 EXTRA STOCK

A. Provide extra stock under provisions of Section 26 05 00.

B. LED Light Engines or Modules: Three (3) percent of quantity installed, minimum of one (1) of each size and type.

C. Lenses: Three (3) percent of quantity installed, minimum of one (1) of each size and type.

D. Ballasts and LED Drivers: Three (3) percent of quantity installed, minimum of one (1) of each size and type.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site. Store and protect under provisions of Section 26 05 00.

B. Protect luminaire finishes, lenses, and trims from damage during storage and installation. Do not remove protective films until construction cleanup within each area is complete.

C. Handle site lighting poles carefully to prevent breakage and damage to finish.

1.6 WARRANTY

A. Fluorescent ballasts shall carry a three-year warranty from date of Substantial Completion. HID ballasts shall carry a two-year warranty from date of Substantial Completion. Dimming electronic ballasts shall have a five year warranty.

B. Emergency fluorescent ballast shall have a five-year warranty from date of substantial completion.

C. Fluorescent lamps shall carry a two-year warranty from date of Substantial Completion.

D. HID lamps shall carry a one-year warranty from date of Substantial Completion.

E. Light emitting diode (LED) light engines and drivers shall have a five-year warranty from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 INTERIOR LUMINAIRES AND ACCESSORIES - GENERAL

A. Lensed Fluorescent Troffers: Provide hinged frames with latches and 0.125-inch thick virgin acrylic lenses. Prismatic lenses shall have depth of no less than 0.080”, KSH12 or equal. Other lenses as scheduled.

B. Recessed Luminaires: Confirm ceiling and wall type and furnish trim and accessories necessary to permit proper installation in each system. Where fire-rated ceiling or wall assemblies are specified, furnish and install listed enclosures around luminaires that maintain the system rating.

C. Parabolic Luminaires: Louvers shall be anodized low iridescent specular aluminum with mitered corners and interlocking construction. Provide ballast covers to separate inboard/outboard lamps when multi-level switching is indicated, so light does not spill into unlit cells.

D. Suspended Luminaires: Coordinate power feed and suspension canopies with ceiling type and architectural RCP for proper fit and location. Ensure finished installations are plumb and level at elevations specified.

E. Exit Signs: Stencil face, 6-inch high letters, directional arrows as indicated, universal mounting type as indicated on the drawings.

F. Self-Powered Exit Signs: Stencil face, 6-inch high letters, directional arrows as indicated, universal mounting type as indicated on the drawings. One-piece, self-contained unit with sealed, maintenance-free nickel cadmium battery, automatic charger and electronic circuitry. Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

G. Self-Powered Emergency Lighting Units: One-piece, self-contained unit with sealed, maintenance-free nickel cadmium battery, automatic charger and electronic circuitry. Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

H. HID Luminaires: Pre-wired, with integral ballast.

I. Painted reflector surfaces shall have a minimum reflectance of 90%.

J. All painted components shall be painted after fabrication.

2.2 EXTERIOR LUMINAIRES AND ACCESSORIES - GENERAL

A. Listed for wet or damp location as scheduled. Fountain and pool luminaires shall be listed for submersible location to meet depth specified.

B. Provide low temperature ballasts or LED drivers, with reliable starting to -20°F.

C. In-grade luminaires shall have lamp/optic separation to prevent surface temperature from exceeding 115°F. Compartment separation of wire entry and control gear/lamp chamber.

2.3 LIGHT EMITTING DIODE (LED) LUMINAIRE SYSTEMS

A. Light emitting diodes used in interior applications shall have a minimum color rendering index (CRI) of 80. Light emitting diodes used in exterior applications shall have a minimum color rendering index (CRI) of 70. Color temperature of the luminaires shall be as noted on the luminaire schedule.

B. LED chip arrays specified as color changing shall have chip colors as noted on the luminaire schedule.

C. LED chips shall be wired so that failure of one chip does not prohibit operation of the remainder of the chip array.

D. LED Driver:

1. Solid state driver with integral heat sink. Driver shall have overheat, short-circuit and overload protection, power factor 0.90 or above and maximum total harmonic distortion of 20%. Surge suppression device for all exterior luminaires.

2. Drivers shall have dimming capabilities as outlined in the luminaire schedule for each luminaire type.

3. Driver shall have a minimum of 50,000 hours rated life.

2.4 ACCEPTABLE MANUFACTURERS - POLES

A. Manufacturer of Luminaire.
B. Valmont Poles.
C. U. S. Pole Company.
D. KW Industries

2.5 LIGHTING POLES

A. Metal Poles: Square straight aluminum lighting pole with anchor base.

B. Laminated Wood Poles: Raceway type lighting pole; pressure treat with alkaline copper quaternary preservative.

C. Wind Load: 100 MPH velocity, with 1.3 gust factor with luminaires and brackets mounted.

D. Hand Hole: 2 x 4 inches with removable weatherproof cover installed at manufacturer's standard location. Provide matching gasketed cover plate.

E. Anchor Bolts: As recommended by pole manufacturer. Provide template, flat washers, lock washers, and hex nuts for each pole. Grout between anchor plate and concrete base with non-shrink grout after pole is plumbed.

F. Vibration Damper: Canister or snake type second mode vibration damper internal to the pole as recommended by pole manufacturer. Provide additional pole top damper for first mode vibration on single-head poles where recommended by manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Securely fasten luminaires to the listed and labeled ceiling framing member by mechanical means such as bolts, screws, rivets or listed clips identified for use with the type of ceiling framing members. If ceiling framing is not listed for luminaire size or weight, support luminaires independent of ceiling grid with a minimum of two (2) #12 gauge wires located on diagonal corners.

B. Install recessed flanged luminaires to permit removal from below. Use manufacturer-supplied plaster frames and swing gate supports. Support luminaires independent of ceiling with a minimum of two (2) #12 gauge wires located on diagonal corners.

C. Support surface-mounted luminaires directly from building structure. Install luminaires larger than eight square feet (8 ft^2) or weighing more than 30 pounds independent of ceiling framing.

D. Support suspended or pendant mounted luminaires independent of ceiling grid with a minimum of two #12 gauge wires. Suspension assembly and anchors shall be capable of supporting 300 pounds dead load at each suspension point.

E. Install lamps in lamp holders of luminaires.

F. Adjust aimable luminaires to obtain lighting levels on objects and areas as directed to obtain desired lighting levels.

G. Parabolic louvers and other optical accessories shall remain in protective wraps or films until construction in area is complete and area has been cleaned.

H. Industrial Pendant Luminaires: Use hangers rated 500 pounds minimum or provide safety chain between ballast and structure. Provide safety chain between reflector and ballast.

I. Luminaire Pole Bases: Sized and constructed as indicated on the drawings. Project anchor bolts 2 inches minimum above base. Install poles plumb with double nuts for adjustment. Grout around pole anchor base.

J. Use belt slings or non-chafing ropes to raise and set pre-finished luminaire poles.

3.2 ADJUSTING AND CLEANING

A. Align luminaires and clean lenses and diffusers at completion of work. Clean paint splatters, dirt, and debris from installed luminaires.

B. Touch up luminaire and pole finish at completion of work.

3.3 LUMINAIRE SCHEDULE

A. As shown on the drawings.

END OF SECTION

SECTION 27 05 00

BASIC COMMUNICATIONS SYSTEMS REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Basic Communications Systems Requirements specifically applicable to Division 27 sections, in addition to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 SCOPE OF WORK

A. This Specification and the accompanying drawings govern the work involved in furnishing, installing, testing and placing into satisfactory operation the Communications Systems as shown on the drawings and specified herein.

B. Each Contractor shall provide all new materials as indicated in the schedules on the drawings, and/or in these specifications, and all items required to make their portion of the Communications Systems a finished and working system.

C. Description of Systems include but are not limited to the following:

1. Complete Structured Cabling System including, but not limited to:

   a. Data backbone cabling and terminations.
   b. Data horizontal cabling and terminations.
   c. Information outlets (IOs) including faceplates, jacks and labeling.
   d. Equipment racks, cabinets, cable management and equipment.
   e. Telecommunication Room equipment including patch panels, optical distribution cabinets, and termination blocks.
   f. Cabling pathways.
   g. Grounding and Bonding
   h. Testing

2. Mounting and patching of wireless access points provided by others.

3. Low Voltage Communications Wiring (less than +120VAC) as specified and required for proper system control and communications.

4. All associated electrical backboxes, conduit, miscellaneous cabling, and power supplies required for proper system installation and operation as defined in the "Suggested Matrix of Scope Responsibility".

5. Firestopping of penetrations as described in Section 26 05 03.

1.3 DIVISION OF WORK BETWEEN ELECTRICAL AND COMMUNICATIONS CONTRACTORS

A. Division of work is the responsibility of the Prime Contractor. Any scope of work described in the contract document shall be sufficient for including said requirement in the project. The Prime Contractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described in the contract documents. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Electrical Contractor" as referred to herein refers to the Contractors listed in Division 26 of this Specification.

2. “Electrical Contractor” shall also refer to the Contractor listed in Division 27 of this specification when the “Suggested Matrix of Scope Responsibility” indicates the work shall be provided by the EC. Refer to the Contract Documents for the “Suggested Matrix of Scope Responsibility”.

3. “Technology Contractor” as referred to herein refers to the Contractors listed in Division 27 of this Specification.

4. Low Voltage Technology Wiring: The wiring (less than 120VAC) associated with the Technology Systems, used for analog and/or digital signals between equipment.

5. Telecommunications/Technology Rough-in: Relates specifically to the backboxes, necessary plaster rings and other miscellaneous hardware required for the installation and mounting of the telecommunications/technology outlet. Rough-in shall include conduit from the information outlet backbox to above the lay-in ceiling the nearest cable tray. Where surface mounted backboxes are required, conduit shall be routed to above the lay-in ceiling the bottom of the exposed structural joists the nearest cable tray.

C. General:

1. The purpose of these specifications is to outline typical Electrical and Technology Contractor's work responsibilities as related to technology systems including telecommunications rough-in, audio/visual systems rough-in, conduit, cable tray, power wiring, and low voltage communications and technology wiring. The prime contractor is responsible for all divisions of work.

2. The exact wiring requirements for much of the equipment cannot be determined until the systems have been purchased and submittals are approved. Therefore, only known wiring, conduits, raceways, and electrical power as related to such items, is shown on the technology drawings. Other wiring, conduits, raceways, junction boxes, and electrical power not shown on the technology drawings but required for the successful operation of the systems shall be the responsibility of the Technology Contractor and included in the Contractor’s bid.

3. Where the Electrical Contractor is required to install conduit, conduit sleeves and/or power connections in support of technology systems, the final installation shall not begin until a coordination meeting between the Electrical Contractor and the Technology Contractor has convened to determine the exact location and requirements of the installation.

4. Where the Electrical Contractor is required to install cable tray that will contain low voltage technology wiring, the installation shall not begin until the Technology Contractor has completed a coordination review of the cable tray shop drawing.

5. This Contractor shall establish electrical and technology utility elevations prior to fabrication and installation. The Technology Contractor shall cooperate with the Electrical Contractor and the determined elevations in accordance with the guidelines below. This Contractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

   a. Lighting Fixtures
   b. Gravity Flow Piping, including Steam and Condensate
   c. Sheet Metal
   d. Electrical Busduct
   e. Cable supports, including 12” access space
   f. Sprinkler Piping and other Piping
   g. Conduit and Wireway
   h. Open Cabling

D. Electrical Contractor's Responsibility:

1. Assumes all responsibility for all required conduit and power connections when shown on the “Suggested Matrix of Scope Responsibility” to be provided by the Electrical Contractor.

2. Responsible for Communications Systems grounding and bonding.

3. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

E. Technology Contractor’s Responsibility:

1. Assumes all responsibility for the low voltage technology wiring of all systems, including cable support where open cable is specified.

2. Assumes all responsibility for all required backboxes, conduit and power connections not specifically shown as being provided by the Electrical Contractor on the “Suggested Matrix of Scope Responsibility.”

3. Assumes all responsibility for providing and installing all ladder rack and other cable management hardware (as defined herein).

4. Responsible for providing the Electrical Contractor with the required grounding lugs or other hardware for each piece of technology equipment which is required to be bonded to the technology bonding system.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.4 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

   a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.

   b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5” and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

   c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5” and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

   d. Maintenance clearances and code-required dedicated space shall be included.

   e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.

2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

   a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

    a. Scale of drawings:

        1) General plans: 1/4 Inch = 1 '-0" (minimum).

        2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).

        3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).

        4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1 '-0" (minimum).

        5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.

3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.

4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.

2. A plotted set of coordination drawings shall be available at the project site.

3. Coordination drawings are not shop drawings and shall not be submitted as such.

4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.

5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.

6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.

7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.

9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

   a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.

   b. Potential layout changes shall be made to avoid additional access panels.

   c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

   d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.

   e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain signoff of the drawings by all contractors prior to installing any of the components.

11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.

12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.5 QUALITY ASSURANCE

A. Telecommunications Structured Cabling System Standards:

1. All work and equipment shall conform to the most current ratified version of the following published standards unless otherwise indicated that draft standards are to be followed:

   a. ANSI/NECA/BICSI 568 - Standard for Installing Commercial Building Telecommunications Cabling

b. ANSI/TIA-568-C.0 - Generic Telecommunications Cabling for Customer Premises

1) C.1 - Commercial Building Telecommunications Standard

2) C.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standard

3) C.3 - Optical Fiber Cabling Components Standard

4) C.4 - Broadband Coaxial Cabling and Components Standard

c. ANSI/TIA-569-C - Telecommunications Pathways and Spaces

d. ANSI/TIA-606-B - Administration Standard for Commercial Telecommunications Infrastructure

e. ANSI/TIA-607-B - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

f. ANSI/TIA-758-B - Customer-Owned Outside Plant Telecommunications Standard

g. ANSI/TIA-862-A - Building Automation Systems Cabling Standard

h. ANSI/TIA-942-A - Telecommunications Infrastructure Standard for Data Centers

i. ANSI/TIA-1152 - Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling

j. ANSI/TIA/EIA-598-C - Optical Fiber Cable Color Coding

k. NFPA 70 (NEC) - National Electrical Code (Current Edition)

l. UL 444 - Standard for Safety for Communications Cable

B. Refer to individual sections for additional Quality Assurance requirements.

C. Qualifications:

1. Only products of reputable manufacturers as determined by the Architect/Engineer will be acceptable.

2. The installing Contractor shall be <u>certified</u> by the manufacturer of the structured cabling system. Certification of Contractor shall have been in place for a minimum of one (1) year prior to bidding this project. Documentation of certification is required at the time of bid. Shop drawings will not be approved until proof of certification is submitted. Refer to the end of this specification section for certification documentation requirements.

3. Each Contractor and their subcontractors shall employ only workers who are skilled in their respective trades and fully trained. All workers involved in the termination of cabling shall be individually certified by the manufacturer.

4. The Contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size.

5. The Contractor shall own and maintain tools and equipment necessary for successful installation and testing of optical and copper structured cabling systems and have personnel adequately trained in the use of such tools and equipment.

6. The Contractor shall obtain the services of a BICSI RCDD (Registered Communications Distribution Designer) or CNet CNIDP (Certified Network Infrastructure Design Professional) for the project. The RCDD or CNIDP shall perform the following tasks on the project:

   a. Review contractor's submittals and stamp the submittals stating the submittals compliance with the contract documents.

   b. Provide written and dated confirmation of an observation of the contractor's installation activities no less than every [2 weeks] [month] during the construction period.

   c. Provide a final written and dated confirmation of a final construction review prior to testing.

   d. Review final testing of system and indication that the documented results or transmittal of the results stating the test results compliance with the contract documents.

7. The Contractor shall have certified BICSI installation technicians or CNet CNIT (Certified Network Infrastructure Technician) on staff to perform the following tasks on the project:

   a. Act as the field superintendent or job foreman with the responsibility of monitoring the daily work of each technician.

   b. Oversee all testing and termination of cabling.

8. The Contractor shall have certified BICSI Installer 2 or CNet CNCI (Certified Network Cabling Installer) on staff to perform the following tasks:

   a. Installation and termination of copper cable.
   b. Installation and termination of optical fiber.

9. A resume of qualification shall be submitted with the Contractor's bid indicating the following:

   a. Documentation of certification of This Contractor by the proposed structured cabling system manufacturer as required at the end of this specification section.

   b. A list of recently completed projects of similar type and size with contact names and telephone numbers for each.

   c. A list of test equipment proposed for use in verifying the installed integrity of copper and fiber optic systems on the project.

d. A technical resume of experience for the Contractor's project manager and on-site installation supervisor assigned to this project.

e. Resume and certification of the RCDD or CNIDP for the project as required by the form at the end of this specification section.

f. Resume and certification of the BICSI installation technician or CNet CNIT for the project.

D. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of Madison, Wisconsin's Codes, Laws, Ordinances and other regulations having jurisdiction.

2. In the event there are no local codes having jurisdiction over this job, the current issue of the National Electrical Code shall be followed.

3. If there is a discrepancy between the codes and regulations having jurisdiction over this installation, and these specifications, Architect/Engineer shall determine the method or equipment used.

4. If the Contractor notes, at the time of bidding, any parts of the drawings and specifications which are not in accordance with the applicable codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time to follow this procedure, he shall submit with the proposal, a separate price required to make the system shown on the drawings comply with the codes and regulations.

5. Verify the installation environment prior to purchasing or installing any cable. Cable installed in a plenum environment shall be appropriately rated. Bring all discrepancies between the contract documents and installation conditions to the attention of the Architect/Engineer prior to purchase or installation.

6. All changes to the system made after the letting of the contract, in order to comply with the applicable codes or the requirements of the Inspector, shall be made by the Contractor without cost to the Owner.

E. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all applicable laws, regulations, ordinances, and other rules of the State or Political Subdivision wherein the work is done, or as required by any duly constituted public authority.

3. Pay all applicable charges for such permits or licenses that may be required.

4. Pay all applicable fees and taxes imposed by the State, Municipal and/or other regulatory bodies.

5. Pay all charges arising out of required inspections due to codes, permits, licenses or as otherwise may be required by an authorized body.

6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized independent agency/consultant.

7. Pay any charges by the service provider related to the service or change in service to the project.

8. All equipment and materials shall be as approved or listed by the following (unless approval or listing is not applicable to an item by all acceptable manufacturers):

   a. Factory Mutual
   b. Underwriters' Laboratories, Inc.

F. Examination of Drawings:

1. The drawings for the technology systems work are diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment etc., and the approximate sizes of equipment.

2. Contractor shall determine the exact locations of equipment and the exact routing of cabling to best fit the layout of the job. Scaling of the drawings will not be sufficient or accurate for determining this layout. Where a specific route is required, such route will be indicated on the drawings.

3. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

4. If an item is either shown on the drawings, called for in the specifications or required for proper operation of the system, it shall be considered sufficient for including same in this contract.

5. The determination of quantities of material and equipment required shall be made by the Contractor from the drawings. Schedules on the drawings and in the specifications are completed as an aid to the Contractor but where discrepancies arise, the greater number shall govern.

6. Where words "provide", "install", or "furnish" are used on the drawings or in the specifications, it shall be taken to mean, to furnish, install and terminate completely ready for operation, the items mentioned.

G. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed “Electronic File Transmittal” form provided by IMEG.

4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor's use of these documents.

H. Field Measurements:

1. Before ordering any materials, this Contractor shall verify all pertinent dimensions at the job site and be responsible for their accuracy.

2. Field conditions that will result in telecommunications drops that exceed the length limitations identified in the contract documents shall be brought to the attention of the Architect/Engineer prior to installation. The cost of reworking cabling that is too long, that was not brought to the written attention of the Architect/Engineer will be borne entirely by the Contractor.

3. This Contractor shall provide the Architect/Engineer with written documentation of any cabling drops that will not be able to use the cable tray (where cable tray is available) due to the resulting cabling lengths. This documentation shall be submitted prior to installation and installation shall not commence until approved by the Architect/Engineer.

1.6 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	Submittal Item
27 05 03	Through Penetration Firestopping
27 05 26	Communications Bonding
27 05 28	Interior Communications Pathways
27 05 43	Exterior Communications Pathways
27 05 53	Identification and Administration
27 11 00	Communication Equipment Rooms
27 13 00	Backbone Cabling Requirements
27 15 00	Horizontal Cabling Requirements
27 17 10	Testing

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

   a. Date
   b. Project title and number
   c. Contractor’s name and address
   d. Description of items submitted and relevant specification number
   e. Notations of deviations from the contract documents
   f. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

   a. Date
   b. Project title and number
   c. Architect/Engineer
   d. Contractor and subcontractors’ names and addresses
   e. Supplier and manufacturer’s names and addresses
   f. Description of item submitted (using project nomenclature) and relevant specification number
   g. Notations of deviations from the contract documents
   h. Other pertinent data
   i. Provide space for Contractor’s review stamps

3. Composition:

   a. Submittals shall be submitted using specification sections and the project nomenclature for each item.

   b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).

   c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

5. Contractor’s Approval Stamp:

   a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.

   b. Unstamped submittals will be rejected.

c. The Contractor shall provide proof of RCDD or CNIDP review on the submittal.

d. The Contractor's review shall include, but not be limited to, verification of the following:

1) Only approved manufacturers are used.
2) Addenda items have been incorporated.
3) Catalog numbers and options match those specified.
4) Performance data matches that specified.
5) Electrical characteristics and loads match those specified.
6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
7) Dimensions and service clearances are suitable for the intended location.
8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

e. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.

f. **The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.**

6. Submittal Identification and Markings:

a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.

b. The Contractor shall clearly indicate the size, finish, material, etc.

c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.

d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.

8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.

9. Reproduction of contract documents alone is not acceptable for submittals.

10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.

11. Submittals not required by the contract documents may be returned without review.

12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.

13. Submittals shall be reviewed and approved by the Architect/Engineer **before** releasing any equipment for manufacture or shipment.

14. Contractor’s responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer’s approval.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. Submittal file name: 27 XX XX.description.YYYYMMDD
   b. Transmittal file name: 27 XX XX.description.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be transmitted via a pre-approved method.

1.7 SCHEDULE OF VALUES

A. The requirements herein are in addition to the provisions of Division 1.

B. Format:

1. Use AIA Document Continuation Sheets G703 or another similar form approved by the Owner and Architect/Engineer.
2. Submit in Excel format.
3. Support values given with substantiating data.

C. Preparation:

1. Itemize work required by each specification section and list all providers. All work provided by subcontractors and major suppliers shall be listed on the Schedule of Values. List each subcontractor and supplier by company name.

2. Break down all costs into:

a. Material: Delivered cost of product with taxes paid.
b. Labor: Labor cost, excluding overhead and profit.

1.8 CHANGE ORDERS

A. A detailed material and labor take-off shall be prepared for each change order along with labor rates and mark-up percentages. Change orders with inadequate breakdown will be rejected.

B. Change order work shall not proceed until authorized.

1.9 EQUIPMENT SUPPLIERS' INSPECTION

A. The following equipment shall not be placed in operation until a representative of the manufacturer has inspected the installation and certified that the equipment is properly installed and that the equipment is ready for operation:

1. Firestopping, including mechanical firestop systems.

1.10 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to prevent damage to fixtures, equipment and materials.

B. Store materials on the site to prevent damage.

C. Keep fixtures, equipment and materials clean, dry and free from deleterious conditions.

1.11 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.12 WARRANTY

A. At a minimum, provide a one (1) year warranty for all equipment, materials, and workmanship. Individual specifications sections within Division 27 may require additional warranty requirements for specific equipment or systems.

B. The warranty period for the entire installation described in this Division of the specifications shall commence on the date of substantial completion unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner or their representative.

C. Warranty requirements shall extend to correction, without cost to the final user, of all work and/or equipment found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from such defects or nonconformance with contract documents exclusive of repairs required as a result of improper maintenance or operation, or of normal wear as determined by the Architect/Engineer.

1.13 INSURANCE

A. This Contractor shall maintain insurance coverage as set forth in Division 1 of these specifications.

1.14 MATERIAL SUBSTITUTION

A. Where several manufacturers' names are given, the first named manufacturer constitutes the basis for job design and establishes the equipment quality required.

B. Equivalent equipment manufactured by the other named manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meets all requirements of the drawings and specifications and fits in the allocated space. The Architect/Engineer shall make the final determination of whether a product is equivalent.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer via addendum. The Contractor bears full responsibility for the unnamed manufacturers equipment adequately meeting the intent of design. The Architect/Engineer may reject manufacturer at time of shop drawing submittal. The Contractor assumes all costs incurred by other trades on the project as a result of changes necessary to accommodate the offered material, equipment or installation method.

D. Should this Contractor be unable to secure approval from the Architect/Engineer for other unnamed manufacturers as outlined above, this Contractor may list voluntary add or deduct prices for alternate materials on the bid form. These items will not be used in determining the low bidder. Should a voluntary alternate material be accepted, This Contractor shall assume all costs that may be incurred as a result of using the offered material, article or equipment necessitating extra expense on This Contractor or on the part of other Contractors whose work is affected.

PART 2 - PRODUCTS

2.1 Cable Jacket Rating: This project requires all inside plant cable jackets to carry a plenum rating. Refer to individual sections.

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or his or her employees and subconsultants at a construction site, shall relieve the Contractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Installation of all conduit and cabling shall comply with Sections 26 05 33 and 26 05 13. Additional conduit requirements described within this Division shall be supplemental to the requirement described in Section 26 05 33. Should conflicts exist between the two Divisions the more stringent (more expensive material and labor) condition shall prevail until bidding addendum or construction clarification or RFI can be submitted and responded to. In no case shall the Contractor carry the least stringent condition in the pricing.

B. It is the Contractor's responsibility to survey the site and include all necessary costs to perform the installation as specified.

C. All cables and devices installed in damp or wet locations, including any underground or underslab location, shall be listed as suitable for use in such environments. Follow manufacturer's recommended installation practices for installing cables and devices in damp or wet locations. Any cable or device that fails as a result of being installed in a damp or wet location shall be replaced at the Contractor's expense.

3.3 FIELD QUALITY CONTROL

A. General:

1. Refer to specific Division 27 sections for further requirements.

2. The Contractor shall conduct all tests required and applicable to the work both during and after construction of the work.

3. The necessary instruments and materials required to conduct or make the tests shall be supplied by the Contractor who shall also supply competent personnel for making the tests who has been schooled in the proper testing techniques.

4. In the event the results obtained in the tests are not satisfactory, This Contractor shall make such adjustments, replacements and changes as are necessary and shall then repeat the test or tests which disclose faulty or defective work or equipment, and shall make such additional tests as the Architect/Engineer or code enforcing agency deems necessary.

5. All communications cable tests that fail, including those due to excessive cabling lengths, shall be remedied by the Contractor without cost to the project.

B. Protection of cable from foreign materials:

1. It is the Contractor’s responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer’s performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.

2. Application of foreign materials of any kind on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor’s responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

3.4 PROJECT CLOSEOUT

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. The Architect/Engineer will not perform a final jobsite observation until the project is ready. This is not dictated by schedule, but rather by completeness of the project.

2. Refer to the end of this specification section for a “STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION.”

3. The Contractor shall sign this form and return it to the Architect/Engineer so that the final observation can commence.

C. Before final payment will be authorized, this Contractor must have completed the following:

1. Submitted operation and maintenance manuals to the Architect/Engineer for review.

2. Submitted bound copies of approved shop drawings.

3. Record documents including edited drawings and specifications accurately reflecting field conditions, **inclusive** of all project revisions, change orders, and modifications.

4. Submitted a report stating the instructions given to the Owner's representative complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representative as having received the instructions.

5. Submitted testing reports for all systems requiring final testing as described herein.

6. Submitted start-up reports on all equipment requiring a factory installation inspection and/or start.

7. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site; submit receipt to Architect/Engineer prior to final payment being approved.

8. Provide System Assurance Warranty certificate for the telecommunications system.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.

2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. O&M file name: O&M.div27.contractor.YYYYMMDD

b. Transmittal file name: O&Mtransmittal.div27.contractor.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be divided into files that are clearly labeled as “1 of 2”, “2 of 2”, etc.

6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title “Operation and Maintenance Instructions”, title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.

7. All text shall be searchable.

8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.

2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.

3. Copies of all final approved shop drawings and submittals. Include Architect’s/Engineer’s shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.

4. Copy of final approved test and balance reports.

5. Copies of all factory inspections and/or equipment startup reports.

6. Copies of warranties.

7. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.

8. Dimensional drawings of equipment.

9. Capacities and utility consumption of equipment.

10. Detailed parts lists with lists of suppliers.

11. Operating procedures for each system.

12. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.

13. Repair procedures for major components.

14. List of lubricants in all equipment and recommended frequency of lubrication.

15. Instruction books, cards, and manuals furnished with the equipment.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVE

A. Adequately instruct the Owner's designated representative or representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representative or representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The Architect/Engineer shall be notified of the time and place for the verbal instructions to be given to the Owner's representative so that their representative can be present if desirable.

E. Refer to the individual specification sections for minimum hours of instruction time for each system.

F. Operating Instructions:

1. The Contractor is responsible for all instructions to the Owner and/or Owner’s operating staff on the Communications Systems.

2. If the Contractor does not have Engineers and/or Technicians on staff who can adequately provide the required instructions on system operation, performance, troubleshooting, care and maintenance, they shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 SYSTEM COMMISSIONING

A. The Communications Systems included in the construction documents are to be complete and operating systems. The Architect/Engineer will make periodic job site observations during the construction period. The system start-up, testing, configuration, and satisfactory system performance is the responsibility of the Contractor. This shall include all calibration and adjustments of electrical equipment controls, equipment settings, software configuration, troubleshooting and verification of software, and final adjustments that may be required.

B. All operating conditions and control sequences shall be simulated and tested during the start-up period.

C. The Contractor, subcontractors, and equipment suppliers are expected to have skilled technicians to ensure that the system performs as designed. If the Architect/Engineer is requested to visit the job site for the purpose of trouble shooting, assisting in the satisfactory start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period through no fault of the design; the Contractor shall reimburse the Owner on a time and material basis for services rendered at the Architect/Engineer's standard hourly rates in effect at the time the services are requested. The Contractor shall be responsible for making payment to the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.8 RECORD DOCUMENTS

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Mark specifications to indicate approved substitutions, change orders, and actual equipment and materials used.

C. This Contractor shall maintain at the job site, a separate and complete set of technology drawings which shall be clearly and permanently marked and noted in complete detail any changes made to the location and arrangement of equipment or made to the Technology Systems and wiring as a result of building construction conditions or as a result of instructions from the Architect or Engineer. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable. Should This Contractor fail to complete Record Documents as required by this contract, This Contractor shall reimburse Architect/Engineer for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at the Architect/Engineer's hourly rates in effect at the time of work.

D. Record actual routing of all conduits sized 2" or larger.

E. The above record of changes shall be made available for the Architect and Engineer's examination during any regular work time.

F. Upon completion of the job, and before final payment is made, This Contractor shall give the marked-up drawings to the Architect/Engineer.

3.9 ADJUST AND CLEAN

A. Contractor shall thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project.

B. Contractor shall clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from equipment.

C. Contractor shall remove all rubbish, debris, etc., accumulated during the Contractor's operations from the premises.

END OF SECTION

STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION

To assist the contractor in a timely close-out of the project, it is crucial that the final jobsite observation is not conducted prior to the project being ready. The contractor is required to review the completion status of the project at the time the observation is scheduled. This review, and the subsequent submittal of this form to the Architect/Engineer, shall indicate the contractor's agreement that the area of the project being requested for final observation is ready as defined below. The following list represents the degree of completeness required prior to requesting a final observation:

1. All cabling pathways (cable tray, ladder rack, conduit sleeves, etc.) are installed and all cabling has been pulled through them.
2. All mechanical firestop products are installed and all other penetrations have been sealed.
3. All telecommunications jacks are installed in the faceplates.
4. All telecommunications cabling is pulled and at least 75% of all jacks have been terminated at the jack and at the telecom room.
5. Telecommunications testing is in progress and at least 25% of testing has been completed.
6. Telecommunications labeling has been provided on at least 25% of each type of component requiring a label.
7. All telecommunications related grounding is complete.
8. All CCTV cameras, mounts, cabling and all headend equipment are installed, programmed and operational.
9. All access control system equipment, including card readers, conduits, cabling, electronic locks, controllers and all headend equipment, is installed, programmed and operational.

The project will be ready for final jobsite observation prior to the requested date of the observation according to the above list of requirements.

Prime Contractor: __________________________ By: ______________________________

Requested Observation Date ________________ Today's Date: _____________________

Contractor shall sign this readiness statement and transmit to Architect/Engineer at least 10 days prior to the requested date of observation.

It is understood that if the Architect/Engineer finds that the project is not complete as defined above and that the final jobsite observation cannot be completed on the requested date, the Architect/Engineer will return to the site at a later date. All additional visits to the site for the purposes of completing the final observation will be billed T&M to the Contractor at our standard hourly rates, including travel expenses or the contractor's retainage may be deducted for the same amount.

Telecommunications – Proof of Certification

There are specific Contractor qualification requirements for this project as defined in Section 27 05 00, which may include Manufacturer Certification and RCDD or CNIDP credentials. This Proof of Certification document, and the supporting documentation require herein, is required to be submitted at the time of bid to show compliance with the requirements of 27 05 00.

Statement of Compliance:

The named Contractor's base bid is a structured cabling solution from the connectivity manufacturer ___________________. Named Contractor is trained and certified, under the named manufacturer's formal certification program to provide and install all materials and work required by this project. Further, said Contractor is authorized, by the named manufacturer, to offer all product, labor and system assurance warranties required for this project by these contract documents.

The certification of this named manufacturer is valid, current and in effect as of the bid day of this project, the ______ day of _________, 20____.

The named Contractor is not employing any other sub-contractor on the telecommunications portion of this project that does not also meet this certification requirement.

Contractor Company Name: ____

Authorized Representative: (print) ____

Date: _________________ Manufacturer Certification Number (if any): ___________________

If this project requires RCDD certification, complete the following:

RCDD or CNIDP Name: ________________________ RCDD #: ____________ Expiration: ____________

Submit the following with the bid:

- This form.
- Proof of Manufacturer Certification indicated above.
- Proof of RCDD or CNIDP status.

SECTION 27 05 26

COMMUNICATIONS BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bonding Conductors
B. Bonding Connectors
C. Grounding Busbar (TMGB and TGB)
D. Rack-mount Telecommunications Grounding Busbar

1.2 RELATED WORK

A. Section 26 05 33 – Conduit and Boxes
B. Section 26 05 13 – Wire and Cable
C. Section 26 05 26 – Grounding and Bonding
D. Section 26 41 00 – Lightning Protection Systems
E. Section 27 05 00 – Basic Communications Systems Requirements
F. Section 27 05 03 – Through Penetration Firestopping
G. Section 27 11 00 – Communication Equipment Rooms
H. Section 27 05 28 – Interior Communication Pathways
I. Section 27 05 53 – Identification and Administration

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

B. Communications bonding system component, device, equipment, and material manufacturer(s) shall have a minimum of five (5) years documented experience in the manufacture of communications bonding products.

C. The entire installation shall comply with all applicable electrical codes, safety codes, and standards. All applicable components, devices, equipment, and material shall be listed by Underwriters' Laboratories, Inc.

1.4 REFERENCES

A. ANSI/IEEE 1100 – Recommended Practice for Power and Grounding Sensitive Electronic Equipment in Industrial and Commercial Power Systems
B. ANSI/TIA/EIA 568-C – Commercial Building Telecommunications Cabling Standard
C. ANSI/TIA/EIA 569-A – Commercial Building Standard for Telecommunications Pathways and Spaces
D. ANSI/TIA/EIA 606 – Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
E. ANSI/TIA/EIA 758 – Customer Owned Outside Plant
F. ANSI-J-STD-607-A – Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
G. IEEE 81 – IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements
H. IEEE 837 – IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding

I. NFPA 70 – National Electrical Code
J. NFPA 780 – Standard for the Installation of Lightning Protection Systems
K. UL 96 – Lightning Protection Components
L. UL 96A – Installation Requirements for Lightning Protection Systems
M. UL 467 – Grounding and Bonding Equipment

1.5 SUBMITTALS

A. Submit product data and shop drawings under provisions of Section 27 05 00 and Division 1.

B. Provide manufacturer's technical product specification sheet for each individual component type. Submitted data shall show the following:

1. Compliance with each requirement of these documents. The submittal shall acknowledge each requirement of this section, item-by-item, including construction, materials, ratings, and all other parameters identified in Part 2 - Products.

2. Manufacturer's installation instructions indicating application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

C. Provide CAD-generated, project-specific system shop drawings as follows:

1. Provide a system block diagram indicating system configuration, system components, interconnection between components, and conductor routing. The diagram shall clearly indicate all wiring and connections required in the system. When multiple devices or pieces of equipment are required in the exact same configuration (e.g., multiple identical equipment racks or sections of ladder tray), the diagram may show one device and refer to the others as "typical" of the device shown. The diagram shall list room numbers where system equipment will be located.

2. Installation details for all system components.

D. Provide system checkout test procedure to be performed at acceptance.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site under the provisions of Section 27 05 00.

B. Store and protect products under the provisions of Section 27 05 00.

C. Contractor shall exercise care to prevent corrosion of any products prior to installation. Corroded products shall not be acceptable for use on this project.

1.7 SYSTEM DESCRIPTION

A. This section describes the requirements for the furnishing, installation, adjusting, and testing of a complete turnkey communications bonding system, including connection to the electrical ground grid.

B. Performance Statement: This specification section and the accompanying drawings are performance based, describing the minimum material quality, required features, operational requirements, and performance of the system. These documents do not convey every wire that must be installed, every equipment connection that must be made, or every feature and function that must be configured. Based on the equipment constraints described and the performance required of the system as presented in these documents, the Contractor is solely responsible for determining all components, devices, equipment, wiring, connections, and terminations required for a complete and operational system that provides the required performance.

C. This document describes the major components of the system. All additional hardware, subassemblies, supporting equipment, and other miscellaneous equipment required for complete, proper system installation and operation shall be provided by the Contractor.

D. Basic System Requirements:

1. A complete communications bonding infrastructure is required for this project. Refer to the drawings and the requirements of ANSI-J-STD-607-A and NFPA 70 for complete information.

2. The bonding system shall include, but not be limited to, the following major components:

a. Bonding Conductor for Telecommunications (BCT)
b. Telecommunications Main Grounding Busbar (TMGB)
c. Telecommunications Bonding Backbone (TBB)
d. Telecommunications Grounding Busbar(s) (TGB)
e. Rack mount Telecommunications Grounding Busbar(s)
f. Bonding Conductor(s) (BC)
g. Bonding Connectors
h. Bonding system labeling and administration as defined in Section 27 05 53.

1.8 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 27 05 00.

B. Provide final system block diagram showing any deviations from approved shop drawing submittal.

C. Provide floor plans that document the following:

1. Actual locations of system components, devices, and equipment.
2. Actual conductor routing.
3. Actual system component, device, equipment, and conductor labels.

D. Provide statement that system checkout test, as outlined in the approved shop drawing submittal, is complete and test results were satisfactory.

E. Complete all operation and maintenance manuals as described below.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 27 05 00.

B. Submitted data shall include:

1. Approved shop drawings.

2. Descriptions of recommended system maintenance procedures, including:

a. Inspection
b. Periodic preventive maintenance
c. Fault diagnosis
d. Repair or replacement of defective components

PART 2 - PRODUCTS

2.1 BONDING CONDUCTORS

A. Bare Copper:

1. Annealed uncoated stranded conductor.
2. Minimum size 6 AWG.

B. Insulated Copper:

1. Annealed uncoated stranded conductor.

2. Insulation:

a. PVC insulation with nylon outer jacket.
b. Rated ≥ 600 volts.
c. Green.

3. Minimum size 6 AWG.

C. All bonding conductors shall be listed and recognized by a nationally recognized testing laboratory as being suitable for the intended purpose and for installation in the space in which they are installed.

D. Bonding Conductor Sizing

1. All Communications bonding system conductors shall be sized by length as follows:

Length Linear ft (m)	Size (AWG)
Less than 13 (4)	6
14 - 20 (4 - 6)	4
21 - 26 (6 - 8)	3
27 - 33 (8 - 10)	2
34 - 41 (10 - 13)	1
42 - 52 (13 - 16)	1/0
53 - 66 (16 - 20)	2/0
Greater than 66 (20)	3/0

2. The BCT shall be the same size as the TBB or larger.

2.2 BONDING CONNECTORS

A. Acceptable Types:

1. Two-hole compression lug
2. Exothermic weld
3. Irreversible compression

B. Connectors shall be provided in kit form and selected per manufacturer's written instructions.

C. Connectors shall comply with IEEE 837 and UL 467 and be listed for use for specific types, sizes, and combinations of conductors and connected items.

2.3 GROUNDING BUSBAR (TMGB AND TGB)

A. Features:

1. Wall-mount configuration.
2. Listed and recognized by a nationally recognized testing laboratory as being suitable for intended purpose.
3. Hole patterns compliant with BICSI recommendations and ANSI-J-STD-607-A standards.
4. Predrilled holes.
5. Integral insulators.
6. Stainless steel offset mounting brackets.

B. Specifications:

1. Material: Electrolytic tough pitch copper bar with tin plating.

2. Minimum Dimensions: 1/4" thick x 4" high x 12" long.

   a. Increase dimensions and/or quantity furnished and installed as required to accommodate all terminations required by the project, plus 20% spare capacity.

3. Hole pattern shall include:

   a. A minimum of 15 sets of 5/16" holes, 5/8" on center, to accommodate "A" spaced 2-hole compression lugs.

   b. A minimum of three (3) sets of 7/16" holes, 1" on center, to accommodate "C" spaced 2-hole compression lugs.

2.4 RACK-MOUNT TELECOMMUNICATIONS GROUNDING BUSBAR

A. Features:

1. Listed and recognized by a nationally recognized testing laboratory as being suitable for intended purpose.

2. Predrilled holes.

3. Mounts in a standard 19" equipment rack.

B. Specifications:

1. Material: Electrolytic tough pitch copper bar with tin plating.

2. Minimum Dimensions: 3/16" thick x 3/4" high x 19" long.

a. Increase dimensions and/or quantity furnished and installed as required to accommodate all terminations required by the project, plus 20% spare capacity.

3. Hole pattern shall include:

a. A minimum of eight (8) 6-32 tapped lug mounting holes on 1" centers.

b. A minimum of two (2) pairs of 5/16" diameter holes spaced 3/4" apart.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Bonding Requirements:

1. The communications bonding system shall be a complete system. Contractor shall furnish and install all necessary miscellaneous components, devices, equipment, material, and hardware, including, but not limited to, lock washers, paint-piercing washers, hex nuts, compression lugs, insulators, mounting screws, lugs, etc., to provide a complete system.

2. A licensed electrician shall perform all bonding.

3. Comply with the manufacturer's instructions and recommendations for installation of all products.

B. Main Cross Connect and Service Entrance Room Bonding Requirements:

1. Locate the TMGB in the service entrance room unless otherwise noted on the drawings.

2. The location of the TMGB shall be the shortest practical distance from the telecommunications primary lightning protection devices.

3. Bond the telecommunications primary protectors to the TMGB. Maintain a minimum 1 foot (300 mm) separation of the bonding conductor from all DC power cables, switchboard cable, and high frequency cable.

C. Telecommunications Main Ground Bar (TMGB) Requirements:

1. Install TMGB such that it is insulated from its support with a minimum 2" standoff.

2. Bond the TMGB to the electrical service ground via the BCT.

   a. A minimum of 1 foot (300 mm) separation shall be maintained between the BCT and any DC power cables, switchboard cable, or high frequency cables.

3. TMGB shall be bonded to all electrical panels located in the same room or space as the TMGB or in an immediately adjacent space within 20 linear feet of the TMGB. TMGB shall be bonded to all electrical panels providing electrical power to communications equipment located in the same room or space as the TMGB.

4. TMGB shall be bonded to accessible metallic building structure located within the same room or space as the TMGB.

5. All metallic continuous cable pathways, including, but not limited to, cable trays, basket trays, ladder racks, raceways, conduits, conduit sleeves, and fire-rated cable pathway devices, located within the same room or space as the TMGB, shall be bonded to the TMGB.

6. All metallic communications equipment, including, but not limited to, cable pair protectors, surge suppressors, cross-connect frames, patch panels, equipment cabinets, etc., located within the same room or space as the TMGB, shall be bonded to the TMGB.

D. Telecommunications Ground Bar (TGB) Requirements:

1. Provide a TGB in each telecommunications equipment room.

2. Install TGB such that it is insulated from its support with a minimum 2” standoff.

3. Bond each TGB to the TMGB via the TBB.

   a. A minimum of 1 foot (300 mm) separation shall be maintained between the TBB and any DC power cables, switchboard cable, or high frequency cables.

   b. The TBB may be routed from TGB to TGB or as a radial feed to each TGB as the layout requires.

4. When there are multiple telecommunications equipment rooms on <u>each</u> floor in buildings containing more than five stories, the TGBs on the same floor shall be bonded together horizontally using a grounding equalizer (GE) on the first, last, and every third intermediate floor. GE conductors shall be the same size as the TBB.

5. If more than one (1) TGB is provided within the same room or space, they shall all be bonded together via a BC the same size as the TBB.

6. TGBs shall be bonded to accessible metallic building structure located within the same room or space as the TGBs.

7. TGBs shall be bonded to all electrical panels located in the same room or space as the TGB or in an immediately adjacent space within 20 linear feet of the TGB. TGBs shall be bonded to all electrical panels providing electrical power to communications equipment located in the same room or space as the TGB.

8. All metallic continuous cable pathways, including, but not limited to, cable trays, basket trays, ladder racks, raceways, conduits, conduit sleeves, and fire-rated cable pathway devices, located within the same room or space as the TGB, shall be bonded to the TGB.

9. All metallic communications equipment, including, but not limited to, cable pair protectors, surge suppressors, cross-connect frames, patch panels, equipment cabinets, etc., located within the same room or space as the TGB, shall be bonded to the TGB.

E. Rack-mount Telecommunications Ground Bar Requirements (RTGB):

1. Provide a rack-mount telecommunications ground bar in each equipment rack.

2. Install RTGB such that it is electrically bonded to the rack. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond between RTGB and equipment rack.

3. Bond each RTGB to the TGB via a BC.

4. If more than one (1) RTGB is provided within the same room or space, they shall all be bonded together via a BC.

5. All contractor-furnished and/or contractor-installed metallic communications equipment, including, but not limited to patch panels, fiber optic distribution enclosures, splice enclosures, active electronics, uninterruptible power supplies, etc., mounted within the same equipment rack as the RTGB, shall be bonded to the RTGB. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond between equipment rack and installed metallic communications equipment. Active electronics and uninterruptible power supplies shall be bonded to the RTGB via a dedicated BC for each device.

F. Metallic Interior Communication Pathway Bonding Requirements:

1. All metallic interior continuous communication cable pathways, including, but not limited to, conduit, conduit sleeves, fire-rated cable pathway devices, cable tray, basket tray, and ladder rack, shall be bonded to the communications bonding system.

G. Bonding Conductor Requirements:

1. Bonding conductors shall be green or marked with a distinctive green color.

2. Bonding conductors shall be routed parallel and perpendicular to building structure along shortest and straightest paths possible. Number of bends and changes in direction should be minimized. Install and secure conductors in a manner that protects the conductors from impact and from physical or mechanical strain or damage.

3. Bonding conductors shall not be installed in metallic conduit.

4. All conductors, including, but not limited, to the BCT, TBB, GE(s), and BC(s), shall be installed splice-free. If the Contractor believes that site conditions do not allow a splice-free installation, the Contractor may request permission from the Architect/Engineer to splice a specific communications bonding system conductor.

    a. Where documented permission to splice a conductor is granted:

        1) The number of splices shall be limited to as few as possible.

        2) Splices shall be made using exothermic welding or irreversible compression-type connections only. Splice hardware shall be listed for grounding and bonding. Solder is not an acceptable means of splicing conductors.

        3) Splices shall be made in telecommunications spaces in accessible locations to facilitate future inspection and maintenance.

        4) Splices shall be adequately supported and protected from impact and from physical or mechanical strain or damage.

5. All bonding conductors shall be labeled in accordance with the requirements of Section 27 05 53. In addition to the requirements of Section 27 05 53:

    a. Labels shall be nonmetallic.

    b. Labels shall be printer-generated.

    c. Labels shall be located on conductors as close as is practical to their point of termination in a readable position.

    d. Additionally, conductors shall be labeled as follows:

        1) "IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL THE BUILDING TELECOMMUNICATIONS MANAGER."

6. Interior water piping is not acceptable for use as a communications bonding system bonding conductor.

7. Metallic cable shields are not acceptable for use as communications bonding system bonding conductors.

H. Bonding Connection Requirements:

1. Make all connections in accessible locations to facilitate future inspection and maintenance.

2. Communications bonding system connections shall be made using exothermic welding, two-hole compression lugs, or other irreversible compression-type connections. <u>The use of 1-hole lugs is prohibited</u>, except for connections to a rack-mount telecommunications ground bar. Connection hardware shall be listed for grounding and bonding. Sheet metal screws shall not be used to make communications bonding system connections.

3. Thoroughly clean conductors before installing lugs and connectors.

4. Install and tighten all connectors in accordance with manufacturer's instructions, using the appropriate purpose-designed tool(s) recommended by the manufacturer for that purpose. Exercise care not to tighten connectors beyond manufacturer's recommendations.

5. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond at all connections.

6. All bonding connections shall be coated in anti-oxidant joint compound that is purpose-designed and purpose-manufactured for that use. Anti-oxidant joint compound shall be applied in accordance with manufacturer's recommendations and instructions.

7. All installed connectors on conductors installed in damp locations shall be sealed with dielectric grease and then covered with heat shrink tubing to protect against moisture ingress. Applied heat shrink tubing shall overlap conductor's outer jacket a minimum of four (4) inches past connector and be installed in accordance with manufacturer's recommendations and instructions.

3.2 FIELD QUALITY CONTROL

A. Field inspection and testing shall be performed under provisions of Section 27 05 00.

B. Where these specifications require a product or assembly without the use of a brand or trade name, provide a product from a reputable manufacturer that meets the requirements of the specifications.

C. Periodic observations will be performed during construction to verify compliance with the requirements of the specifications. These services do not relieve the Contractor of responsibility for compliance with the contract documents.

3.3 ADJUSTING

A. Adjust work under provisions of Section 27 05 00.

B. Contractor shall make any and all adjustments to the communications bonding system necessary to ensure that the installed system meets all requirements listed herein. Modifications necessary to comply with listed requirements or to provide specified performance shall be completed by the Contractor at no additional cost to the Owner.

3.4 TESTING

A. Test installed system under provisions of Section 27 17 10.

B. Measure and document resistance to ground at TMGB, each TGB, each RTGB, and each electrical distribution panel bonded to the TMGB or a TGB.

1. Measurements shall be made not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage, and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the fall-of-potential method according to IEEE 81.

2. Measured resistance to ground at TMGB, each TGB, and each RTGB must not exceed 5 ohms Under no circumstances shall any point in the communications bonding system have a lower resistance to ground than that of nearby electrical distribution system components that it is bonded to.

C. Include measurement documentation in test data submitted at completion of project under provisions of Section 27 17 10.

3.5 SYSTEM TRAINING

A. All labor and materials required for on-site system training shall be provided. Training shall be conducted at the project site using the project equipment.

1. Provide two week's advanced notice of training to the Owner and Architect/Engineer.

2. The Architect/Engineer shall be presented with the option to attend the training.

3. Provide a training outline agenda describing the subject matter and the recommended audience for each topic.

B. At a minimum, the following training shall be conducted:

1. A course detailing the system functions and operations that a technical user will encounter. Provide training on all aspects of using the system, including making new bonding connections to the TMGB, TGB, or RTGB. Provide training on all recommended inspection, maintenance, and repair procedures for the system.

END OF SECTION

SECTION 27 05 28

INTERIOR COMMUNICATION PATHWAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. The work covered under this section consists of the furnishing of all necessary labor, supervision, materials, equipment, tests and services to install complete cable support systems, conduits, sleeves, etc. for an interior cabling plant as shown on the drawings.

1.2 RELATED WORK

A. Section 26 05 33 - Conduit and Boxes
B. Section 27 05 00 - Basic Communications Systems Requirements
C. Section 27 05 26 - Communications Bonding

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for requirements.

1.4 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code

1.5 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering all products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

2. Manufacturer's installation instructions.

B. Coordination Drawings:

1. Include cable tray and conduit sleeve layout in composite electronic coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

1.6 DRAWINGS

A. The drawings, which constitute a part of these specifications, indicate the general route of the wire mesh support systems, conduit, sleeves, etc. Data presented on these drawings is as accurate as preliminary surveys and planning can determine until final equipment selection is made. Accuracy is not guaranteed and field verification of all dimensions, routing, etc., is required.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Refer to Section 26 05 33 for conduit requirements for this project.

2.2 CABLE HANGERS AND SUPPORTS

A. Provide a non-continuous cable support system suitable for use with open cable.

B. Cable Hooks:

1. Construction: Flat bottom design with a minimum cable bearing surface of 1-5/8”. Hooks shall have 90-degree radius edges.

2. All cable hook mounting hardware shall be recessed to prevent damage to cable during installation. Installed cabling shall be secured using a cable latch retainer that shall be removable and reusable.

3. Finish: Pre-galvanized steel, ASTM A653 suitable for general duty use.

C. Cable Hangers:

1. Adjustable, non-continuous cable support slings for use with low voltage cabling.

2. Steel and woven laminate construction, rated for indoor non-corrosive use. Laminate material shall be suitable for use in plenum environments.

3. Sling length shall be adjustable to a capacity of 425 4-pair UTP cables.

4. Cabling hanger load limit shall be 100 lbs per foot.

5. Manufacturer: Erico Caddy, CableCat CAT425, Arlington Fittings Tl Series or approved equal.

PART 3 - EXECUTION

3.1 CABLE HOOK SUPPORT SYSTEM

A. In areas where cabling is not supported by cable tray, ladder rack, enclosed wireway or installed in conduit, such cabling shall be supported by an approved cable hook support system.

B. Refer to manufacturer’s requirements for allowable fill capacity for selected cable hook. In no case shall a 40% fill capacity be exceeded.

C. Cable hooks shall be securely mounted per manufacturer’s instructions. In no case shall the side-to-side travel of any cable hook exceed 6”.

D. Cable hooks shall be selected based on the contractor’s cable routing. Hooks shall be capable of supporting a minimum of 30 pounds with a safety factor of 3.

E. Support spans shall be based on the manufacturer’s load ratings. In no case shall a 5-foot span be exceeded.

F. The resting and supporting of cabling on structural members shall not meet the requirements for cabling support specified herein.

G. The use of tie-wraps or hook and loop type fasteners is specifically prohibited as a substitute for cable hooks specified herein.

3.2 CONDUIT AND CABLE ROUTING

A. Refer to specification section 26 05 03 for additional requirements.

B. All conduits shall be reamed and shall be installed with a nylon bushing.

C. Maintain appropriate conduit bend radius at all times. For conduits with an internal diameter of 2” or less, maintain a bend radius of at least 6 times the internal diameter. For conduits with an internal diameter greater than 2”, maintain a bend radius of at least 10 times the internal diameter.

D. No conduit or sleeve containing more than two (2) cables shall exceed 40% fill ratio, regardless of length.

E. Any conduit exceeding 90’ in length or containing more than two (2) 90-degree bends shall contain a pull box sized per ANSI/TIA/EIA 569 requirements.

1. A separate pull box is required for each 90’ (or greater) length section.

2. A separate pull box is required after any two (2) consecutive 90-degree bends.

3. Pull box shall be located in an area that maintains accessibility of box, including the ability to remove box lid without removal or relocation of any other materials.

F. Any conduit with bends totaling 90 degrees or more shall have the fill capacity derated by 15% for each 90 degrees of cumulative bend.

G. Cables installed in any conduits that do not meet the above requirements shall be replaced at the Contractor’s expense, after the conduit condition has been remedied.

3.3 ATTACHMENT TO METAL DECKING

A. Where supports for cable trays and cable hook systems attach to metal roof decking, excluding concrete on metal decking, do not exceed 25 lbs. per hangar and a minimum spacing of 2’-0” on center. This 25-lb. load and 2’-0” spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

END OF SECTION

SECTION 27 05 43

EXTERIOR COMMUNICATION PATHWAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements relating to furnishing and installing exterior racks, ladders, conduits, sleeves, innerduct, etc. for an exterior cabling plant.

1.2 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

B. Precast Manufacturer (if applicable): Company specializing in precast concrete structures with three (3) years documented experience.

1.3 REFERENCES

A. Section 27 05 00 – Basic Communications Systems Requirements.
B. AASHTO HS-20 - Standard Specification for Highway Bridges.
C. ANSI/ASTM A153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
D. ANSI/ASTM A569 - Steel, Sheet and Strip, Carbon (0.15 Maximum Percent), Hot-Rolled, Commercial Quality.
E. ASTM A48 - Gray Iron Castings.
F. ASTM A123 - Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strips.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer’s data covering <u>all</u> products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

2. Manufacturer’s installation instructions.

B. Manhole submittal (if applicable): Indicate material specifications, dimensions, capacities, size and location of openings, reinforcing details, and accessory locations.

1. Provide product data for manhole accessories.

C. Submit shop drawings and product data under provisions of Section 27 05 00.

D. Submit manufacturer's installation instructions under provisions of Section 27 05 00.

E. Coordination Drawings:

1. Include manholes, hand holes, and conduits 1.5” and larger in coordination files. Include all in--floor and underfloor conduit in coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

1.5 REGULATORY REQUIREMENTS

A. Equipment and material shall be UL (Underwriters Laboratory) listed and labeled.

PART 2 - PRODUCTS

2.1 OUTSIDE PLANT CONDUIT

A. Rigid Metallic Conduit (RMC) and Fittings:

1. Rigid steel conduit hot-dipped galvanized inside and out with threaded ends meeting ANSI C80.1.

2. Fittings and Conduit Bodies:

a. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.

b. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.

c. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.

d. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. **High impact phenolic threaded type bushings are not acceptable.**

e. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

3. Acceptable Manufacturers:

a. Allied, LTV, Steelduct, Wheatland Tube Co, O-Z Gedney, or pre-approved equal.

B. Rigid Non-Metallic Conduit (RNC) and Fittings:

1. UL listed, NEMA TC2 and TC6 Schedule 40 or 80 rigid polyvinyl chloride (PVC) approved for direct burial without concrete encasement.

2. Fittings: NEMA TC3 and TC9, sleeve type suitable for and manufactured especially for use with the conduit by the conduit manufacturer.

3. Plastic cement for joining conduit and fittings shall be provided as recommended by the manufacturer.

4. Acceptable Manufacturers:

    a. Carlon (Lamson & Sessions) Type 40, Cantex, J.M. Mfg., or pre-approved equal.

C. Fittings:

1. Sweeps: Factory manufactured RMC wrapped with 4 mil vinyl tape with a bend radius as follows:

    a. Conduit internal diameter of 2” or less is 6 times the internal conduit diameter.

    b. Conduit internal diameter of more than 2” is 10 times the internal conduit diameter.

2. End Caps (Plugs): Pre-manufactured and watertight. Tape is not an acceptable end cap or cover.

2.2 HAND-HOLES

A. Type:

1. Polymer concrete

B. Dimensions:

1. 24X36X 30.

C. Requirements:

1. Includes polymer concrete cover.

D. Acceptable Manufacturers

1. Quazite
2. Old Castle Precast Christy®
3. New Basis.

2.3 TEXTILE INNERDUCT

A. Contractor shall provide and install innerduct in each conduit identified to have copper and fiber optic cable installed.

B. Innerduct shall have an 18 gauge solid copper core tracer wire installed into each cell to allow for detection by industry standard toning equipment.

C. Each innerduct cell shall have a pull tape installed.

D. Acceptable Manufacturers:

1. Maxcell or pre-approved equal.

2.4 UNDERGROUND WARNING TAPE

A. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, compounded for direct-burial service.

B. Overall Thickness: 5 mils (0.125 mm).

C. Foil Core Thickness: 0.35 mil (0.00889 mm).

D. Orange colored tape 3-wide with 1-inch high black letters permanently imprinted with "CAUTION – BURIED COMMUNICATIONS LINE BELOW". Printing on tape shall be permanent and shall not be damaged by burial operations.

E. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

F. Comply with ANSI Z535.1 through ANSI Z535.5.

PART 3 - EXECUTION

3.1 INSTALLATION - DUCTBANK

A. Make duct bank installations and penetrations through foundation walls watertight.

B. Top of duct banks shall be a minimum of 24 inches below grade, unless otherwise indicated on drawings.

C. Assemble duct banks using non-magnetic saddles, spacers and separators. Position separators to provide 3-inch minimum separation between the outer surfaces of the ducts.

D. Transition from non-metallic to galvanized rigid steel conduit where duct banks enter buildings, manholes, and handholes.

E. Where ducts enter structures such as manholes, handholes, pullboxes and buildings, terminate the ducts in suitable end bells.

F. Slope duct runs for drainage toward manholes and away from buildings with a slope of approximately 3-inches per 100 feet.

G. After completion of the duct bank and prior to pulling cable, pull a mandrel, not less than 12 inches long and with a cross section approximately 1/4 inch less than the inside cross section of the duct, through each duct. Then pull a rag swab or sponge through to make certain that no particles of earth, sand, or gravel have been left in the duct.

H. Plug and seal empty spare ducts entering buildings and structures. Seal watertight all ducts in use entering buildings and structures.

3.2 INSTALLATION – TEXTILE INNERDUCT

A. Provide two (2) 3-cell innerducts per 4" conduit or as recommended by the manufacturer.

B. Install innerduct per manufacturer's guidelines.

C. Cut and tie off innerduct and pull tape inside each communications vault or Entrance Room.

3.3 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. The Contractor shall do all necessary excavating, securing, filling, backfilling, compacting, and restoration in connection with their work.

B. Excavation:

1. Excavations for trenches shall be excavated to proper dimensions to permit installation and inspection of work.

2. Where excavations are carried in error below indicated levels, thoroughly compacted sand-gravel fill, shall be placed in such excess excavations.

3. Excavations shall be protected against frost action and freezing.

4. Care shall be exercised in excavating so as to not damage surrounding structures, equipment, and buried utilities. In no case shall any major structural footing or foundation be undermined.

5. Excavation shall be performed in all ground characteristics, including rock, if encountered. Each bidder shall visit the premises and determine, by actual observations, borings, or other means, the nature of the soil conditions. The cost of all such inspections, borings, etc., shall be borne by the bidder.

6. In the case where the trench is excavated in rock, a compacted bed with a depth of 3" (minimum) of sand and gravel shall be used to support the conduit unless masonry cradles or encasements are used.

7. Where satisfactory bearing soil is not found at the indicated levels, the Architect/Engineer or their representative shall be notified immediately and no further work shall be done until further instructions are given.

8. Mechanical excavation of the trench to line and grade of the conduit, unless otherwise indicated on the drawings.

C. Dewatering:

1. The Contractor shall be responsible for the furnishing, installation, operation and removal of all dewatering pumps and lines necessary to keep the excavation free of water at all times.

D. Underground Obstructions:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found by calling 811. The Contractor is responsible for obtaining <u>all</u> utility locates for all trades on the project to determine obstructions indicated. The Contractor shall use great care in installing in the vicinity of underground obstruction.

E. Fill and Backfilling:

1. No rubbish or waste material shall be permitted in excavations for trench fill and backfill.

2. The Contractor shall provide the necessary sand for backfilling.

3. Dispose of the excess excavated earth as directed.

4. Soils for backfill shall be suitable for required stability and compaction, clean and free from perishable materials, frozen earth, debris or earth with an exceptionally high void content, and free from stones greater than 4 inches in diameter. Under no circumstances shall water be permitted to rise in unbackfilled trenches after installation has been placed.

5. All trenches shall be backfilled immediately after installation of conduit, unless other protection is directed.

6. All conduit shall be laid on a compacted bed of sand at least 3" deep. Backfill around the conduit with sand, spread in 6" layers, then compact each layer.

7. Use sand for backfill up to grade for all conduit located under building slabs or paved areas. All other conduit shall have sand backfill to 6" above the top of the conduit.

8. The backfilling above the sand shall be placed in uniform layers not exceeding 6" in depth. Each layer shall be placed, then carefully and uniformly tamped, so as to eliminate the possibility of lateral or vertical displacement.

9. Install a warning tape approximately 12 inches below finished grade over all underground duct banks. The identifying warning tape shall be as specified above.

10. Where the fill and backfilling will ultimately be under a building, floor or paving, each layer of fill shall be compacted to 95% of the maximum density as determined by AASHTO Designation T-99 or ASTM Designation D-698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content as determined by AASHTO T-99 or ASTM D-698 test.

11. After backfilling of trenches, no superficial loads shall be placed on the exposed surface of the backfill until a period of 48 hours has elapsed.

3.4 RESTORATION REQUIREMENTS

A. Where soil and sod has been removed, it shall be replaced as soon as possible after backfilling is completed. All areas disturbed by work shall be restored to their original condition. The restoration shall include any necessary topsoiling, fertilizing, liming, seeding, or mulching,

END OF SECTION

SECTION 27 05 53

IDENTIFICATION AND ADMINISTRATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the execution and administration requirements relating to the structured cabling system and its termination components and related subsystems.

B. Identification and labeling.

1.2 RELATED WORK

A. Section 27 05 00 – Basic Communications Systems Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Documentation of labeling scheme.

PART 2 - PRODUCTS

2.1 LABELING

A. Adhesive labels shall meet the requirements of UL 969 (Ref D-16) for legibility, defacement and adhesion. Exposure requirements of UL 969 for indoor and outdoor (as applicable) use shall be met.

B. Insert labels shall meet the requirements of UL 969 for legibility, defacement and general exposure.

C. Labeling shall be consistent for all common elements in the project. This consistency shall include label size, color, typeface an attachment method.

D. Labels incorporating bar codes shall be either Code 39 conforming to USS-39 or Code 128 conforming to USS-128.

1. All Code 39 bar codes shall have a ratio between 2.5:1 and 3.0:1. Provide a minimum “quite zone” of 0.25” on each side of the bar code.

2. A descriptive label for reading by personnel shall be provided with any bar code. Bar codes by themselves are not acceptable.

E. Color Code: Observe the following requirements for color coding:

1. Labels on each end of a cable shall be the same color for each termination.

2. Labels for cross-connects shall be two different colors at each termination fields, representative of the color of that field.

3. Orange (Pantone 15C) shall be used for the demarcation point.

4. Green (Pantone 353C) shall be used for the termination point of network connection on the facility side of the demarc.

5. Purple (Pantone 264C) shall be used to identify the termination of cables from common equipment (PBX, computers, LANS, etc.)

6. White shall be used to identify the first-level backbone termination in the main cross-connect.

7. Gray (Pantone 422C) shall be used to identify the second-level backbone termination in the main cross-connect.

8. Blue (Pantone 291C) shall be used to identify the termination of station cabling at the telecommunications closet and/or equipment room end of the cable.

9. Brown (Pantone 465C) shall be used to identify the termination of the interbuilding backbone cable terminations.

10. Yellow (Pantone 101C) shall be used to identify the termination of auxiliary circuits, alarms, maintenance, security, etc.

11. Red (Pantone 184C) shall be used to identify the termination of key telephone systems.

12. In facilities that do not contain a main cross-connect, the color white may be used to identify second-level backbone terminations.

F. Tag all CAT 6, and optical fiber cables at both the Communications Equipment Room and the information outlets using the following alphanumeric labeling system:

1. (Room Number) - (Outlet Number) - (Jack Number) - (Use).

2. “Outlet Number” shall start with 1 in each room, with additional outlets in each room numbered sequentially.

3. “Jack Number” shall start with 1 for the upper left jack in each outlet, increasing sequentially from left to right and top to bottom across the outlet face.

4. “Use” shall be designated by the following:

   a. “D” for data (RJ-45)

5. Example #1: “109-3-4-D” indicates the bottom right data jack (assuming a 4-port faceplate) in outlet #3 in Room 109.

2.2 DOCUMENTATION/AS-BUILTS/RECORDS

A. General:

1. Upon completion of the installation, the Contractor shall submit as-builts per the requirements of Section 27 05 00 and Division 1. Documentation shall include the items detailed in the subsections below.

2. All documentation, including hard copy and electronic forms shall become the property of the Owner.

B. Record Drawings:

1. The drawings are to include cable routes and outlet locations. Outlet locations shall be identified by their sequential number as defined elsewhere in this document. Numbering, icons and drawing conventions used shall be consistent throughout all documentation provided.

PART 3 - EXECUTION

3.1 IDENTIFICATION AND LABELING

A. Cable Labeling: Backbone and horizontal cables shall be labeled at each end.

1. Provide additional cable labeling at each manhole and pull box.

2. Cables that are routed through multiple pathway segments shall contain reference to all pathway segments in the pathway linkage field.

3. Cables that differ only by performance class shall have a suitable marking or label to indicate the higher performance class. For example, station cabling utilizing the blue color, may include blue with a white stripe to indicate the higher performance class station cabling.

B. Information Outlet Labeling: Tag all voice and data jacks as defined herein.

C. Termination Hardware Labeling:

1. An identifier shall be provided at each termination hardware location or its label.

D. Grounding/Bonding Labeling:

1. The TMGB shall be labeled “TMGB.” There shall be only one TMGB in the facility.

2. Label all TBB conductors connecting to the TMGB with a unique label, located at both ends of the TBB.

3. Each TGB shall be labeled with a unique label.

4. All TBB conductors connecting to the TGB shall be labeled uniquely at each end of the cable.

END OF SECTION

SECTION 27 11 00

COMMUNICATION EQUIPMENT ROOMS (CER)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements related to furnishing and installing equipment for communication equipment rooms.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements
B. Section 27 05 26 - Communications Bonding
C. Section 27 05 28 - Interior Communication Pathways
D. Section 27 15 00 - Horizontal Cabling Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for applicable standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering all products including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

2. Manufacturer's installation instructions.

B. Coordination Drawings:

1. Include ladder racking, equipment racks, cable tray and conduit sleeve layout in composite electronic coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

PART 2 - PRODUCTS

2.1 EQUIPMENT GROUNDING

A. Refer to specification section 27 05 26 for grounding requirements.

B. All equipment required to be grounded shall be provided with a grounding lug suitable for termination of the specified size electrode conductor.

2.2 EQUIPMENT RACKS

A. Where identified on the drawings in Communication Equipment Rooms, equipment racks and/or equipment cabinets shall be furnished and installed by the Contractor to house cable termination components (e.g., copper, optical fiber, coax) and network electronics.

B. The equipment rack shall conform to the following requirements:

1. Standard TIA/EIA 19" Floor Rack:

a. Equipment rack shall be 84" in height, self-supporting and provide a useable mounting height of 45 rack units (RU) (1 RU = 1 ¾”).

b. Channel uprights shall be spaced to accommodate industry standard 19" mounting.

c. Equipment rack shall be double side drilled and tapped to accept 12-24 screws. Uprights shall also be drilled on back to accept cable brackets, clamps, power strip(s), etc. Hole pattern on rack front shall be per TIA/EIA specifications (5/8"-5/8"-1/2"). Hole pattern on the rear shall be at 3" intervals to accept cable brackets.

d. Equipment racks shall be provided with a supply of spare screws (minimum of 24).

e. Equipment racks shall be provided with a ground bar and #6 AWG ground lug.

f. Provide all mounting hardware and accessories as required for a complete installation.

2.3 CABLE MANAGEMENT – VERTICAL AND HORIZONTAL

A. Equipment Racks:

1. Equipment racks shall be equipped with vertical and horizontal cable management hardware in the form of rings and guides. Racks shall incorporate vertical and horizontal covers, to allow an orderly, hidden, routing of copper, optical fiber, and coax jumpers from the modular patch panels and/or 110-type termination blocks to the customer provided network electronics. Vertical and horizontal cable management hardware shall be as follows:

a. Horizontal cable management hardware shall be 16 gauge cold rolled steel construction with six (6) pass-thru holes and seven (7) front-mounted 3.5” steel rod D-rings. Provide with cover designed to conceal and protect cable.

b. At a minimum, horizontal cable management hardware shall be positioned <u>above and below</u> (a) each grouping of two rows of jacks on modular patch panels, <u>and</u> (b) <u>above and below</u> each optical fiber patch panel <u>and</u> (c) each grouping of two rows of F-type connectors on coax patch panels.

c. Vertical cable management hardware shall provide for cable routing on front and rear of each rack and be 14” deep x 6” wide (minimum). Where multiple equipment racks are to be installed, this hardware shall be mounted between the uprights of adjacent equipment racks. Equipment rack uprights and the spacers shall be secured together per manufacturer’s recommendations. Provide with cover designed to conceal and protect cable.

2. Each equipment rack shall be supplied with a minimum of 12 releasable (e.g., "hook and loop") cable support ties.

3. Where cable termination hardware is wall-mounted, the Contractor shall be responsible for establishing a cable pathway for jumpers routed from the equipment rack(s) to the wall. This shall be in the form of slotted ducts or troughs. Routing of jumpers via the overhead cable tray or ladder rack system is NOT acceptable. The proposed method shall be included in the submittals required by this document and shall be approved by the Architect/Engineer prior to installation.

2.4 PATCH PANELS

A. Where identified on the drawings in Communication Equipment Rooms, modular patch panels shall be furnished and installed by the Contractor for termination of copper cable.

B. Copper cabling shall be terminated in Communication Equipment Rooms on modular patch panels consisting of a modular connector system incorporating modular jacks meeting the specifications for the jacks detailed in Section 27 15 00. On wall-mounted panels, this interface shall be accessible from the front of the panel.

C. The largest single modular patch panel configuration shall not exceed 48-Ports. Modular patch panels shall be fully populated (all ports occupied by jacks) and be provided in increments of no less than 12 jacks. High-density modular patch panels will not be accepted.

D. The modular patch panel blocks shall have the ability to seat and cut eight (8) conductors (4 pairs) at a time and shall have the ability of terminating 22- through 26-gauge plastic insulated, solid and stranded copper conductors. Modular patch panel blocks shall be designed to maintain the cables' pair twists as closely as possible to the point of mechanical termination.

E. Modular patch panels shall incorporate cable support and/or strain relief mechanisms to secure the horizontal cables at the termination block and to ensure that all manufacturers minimum bend radius specifications are adhered to.

2.5 OPTICAL FIBER PANELS

A. All terminated optical fibers shall be mated to simplex LC -type couplings mounted on enclosed fiber distribution cabinets. Couplings shall be mounted on a panel that, in turn, snaps into the enclosure. The proposed enclosure shall be designed to accommodate a changing variety of connector types including SC, ST, Fixed Shroud Duplex (e.g., "FDDI Connector"), Biconic, FC, and MT-RJ by changing panels on which connector couplings are mounted. Refer to Section 27 15 00 for coupling requirements.

B. The fiber distribution cabinet shall be sized to accommodate the total fiber count to be installed at each location as defined in the specifications and drawings, including those not terminated (if applicable). Connector panels and connector couplings (sleeves, bulkheads, etc.) adequate to accommodate the number of fibers to be terminated shall be furnished and installed by the Contractor.

C. The fiber distribution cabinet shall be an enclosed assembly affording protection to the cable subassemblies and to the terminated ends. The enclosures shall incorporate a hinged or retractable front cover designed to conceal and protect the optical fiber couplings, connectors, and cable.

D. Access to the inside of the fiber distribution cabinet's enclosure during installation shall be from the front and/or rear. Panels that require any disassembly of the fiber distribution cabinet to gain entry will not be accepted.

E. The fiber distribution cabinet's enclosure shall provide for strain relief of incoming optical fiber cables and shall incorporate radius control mechanisms to limit bending of the optical fiber to the manufacturer's recommended minimums or ½", whichever is larger.

F. All fiber distribution cabinets shall provide protection to both the "facilities" and "user" side of the coupling. The fiber distribution cabinet's enclosure shall be configured to require front access only when patching. The incoming optical fiber cables (e.g., backbone, riser, horizontal, etc.) shall not be accessible from the patching area of the panel. The fiber distribution cabinet's enclosure shall provide a physical barrier to access such optical fiber cables.

G. Where "Loose Buffered" cables are installed, the 250 µm coated optical fibers contained in these cables may be terminated either by (1) splicing of factory-terminated cable assemblies ("pigtails") or (2) the use of a "fan-out" kit. In the latter approach, individual fibers are to be secured in a protective covering, an Aramid (e.g., Kevlar™) reinforced tube for example, with connectors mated to the resulting assembly. In both instances, the proposed termination hardware shall incorporate a mechanism by which cable and subassemblies are secured to prevent damage. Splicing shall be by the "fusion" method. Individual splice loss shall not exceed 0.3 dB for multi-mode fibers. Direct termination of 250 µm coated optical fibers shall not be permitted.

H. Fiber distribution cabinets for horizontal cabling: Where optical fiber horizontal cabling is to be terminated, the enclosure shall be compliant to all the above requirements plus the enclosure shall incorporate a storage mechanism designed to allow simplified identification, access to and termination of individual optical fibers. This may be in the form of a storage cassette, tray or other appropriate mechanism.

I. Optical Fiber Connectors (LC-type) (Multimode/Singlemode):

1. LC-type Optical Fiber Connectors: Shall be used to terminate optical fiber in communication equipment rooms.

2. LC-type optical fiber connector plugs shall be snap-type with an integrated pull-proof design.

3. LC-type optical fiber connector plugs shall incorporate a zirconium ceramic ferrule and shall utilize a factory pre-polish end face to ensure fiber-to-fiber physical contact for low loss and reflections.

4. LC-type optical fiber connector plugs shall accept 1.6mm – 2.0mm and 3.0mm outside diameter fiber.

5. The average insertion loss is 0.3db for multimode and single mode connectors.

6. LC-type optical fiber connector plugs shall meet the following performance criteria:

Test Procedure	Maximum Attenuation Change
Cable Retention (FOTP-6)	0.2 dB
Durability (FOTP-21)	0.2 dB

Test Procedure	Maximum Attenuation Change
Impact (FOTP-2)	0.2 dB
Thermal Shock (FOTP-3)	0.2 dB
Humidity (FOTP-5)	0.2 dB

7. Additional Performance Requirements:

   a. Length: 2.23 inches
   b. Operating Temperature: -40 to 85 degrees C

8. Basis of Design:

   a. Hubbell FCLC Series

2.6 LADDER RACK

A. Provide complete ladder rack system including metallic ladder rack, splice connectors, fastening hardware and other miscellaneous materials as required for a complete installation per manufacturer's recommendations.

B. Steel C-Channel Stringer Style Ladder Rack:

1. Rolled steel siderail stringer, 2" stringer height, 9" spaced welded rungs.

2. Steel shall meet the requirements of ASTM A1011 SS Grade 33.

3. Loading limits shall be 292 lbs/ft for 4 ft spans.

2.7 D-RINGS

A. Rounded edge D-rings for support of cabling in vertical and horizontal configurations.

B. EIA 310D compliant, manufactured from materials meeting UL94-V0 specifications.

C. Provide ¼" screw holes for wall mounting.

2.8 POWER STRIPS

A. Provide power strips on all equipment racks, unless noted otherwise. These power strips shall have the following characteristics:

1. Standard Rack Mount:

   a. TIA/EIA 19" equipment rack mountable.

   b. Compliant with UL-1449 Third Edition and UL-497A.

   c. Provide transient suppression to 12,000-A. Protection shall be in all three modes (line-neutral, line-ground and neutral-ground).

   d. Shall meet or exceed ANSI C62 Category A3 requirements.

e. Provide high-frequency noise suppression as follows:

1) >20-dB @ 50 kHz
2) >40-dB @ 150 kHz
3) >80-dB @ 1 MHz
4) >30-dB @ 6 to 1000 MHz

f. Protection Modes and UL 1449 Clamping Voltage: 475 volt L-N, L-G, and N-G.

g. Components: Nonmodular units composed of 20mm metal oxide varistors (MOV). Series inductors, SAD, or selenium cells may be used in addition to MOVs.

h. Be equipped with a 10-foot power cord.

i. Provide with raised floor twistlock compatible.

2.9 COPPER PATCH CORDS

A. Modular Patch Panel:

1. Provide Category 6 Enhanced copper patch cords for 50% of all assigned ports on the modular patch panel. Of these cords, 60% shall be 3’ in length and 40% shall be 5’ in length. These patch cords shall be the cross-connect between the network electronics and the horizontal RJ-45 modular patch panel. Copper patch cords shall be equipped with a 4-pair RJ-45 connector on each end.

2. Refer to Section 27 15 00 for cable and connector performance requirements.

3. Patch cords shall not be made-up in the field.

4. Basis of Design (Refer to 27 17 20 for Acceptable Manufacturers):

a. Hubbell HC Series

2.10 FIBER PATCH CORDS

A. Optical Fiber Patch Cords (Multimode):

1. Provide 50/125 μm multimode (MM) optical fiber utilizing tight buffer construction for 50% of all assigned ports on the fiber distribution cabinet. These patch cords shall be the cross-connect between the backbone fiber distribution cabinet and the Owner’s network electronics (hub/switch). Optical fiber patch cords shall be equipped with a ceramic tipped LC-type connector on each end and shall be a minimum of 5 feet (1.5m) in length. Connector body shall be of materials similar to that used in the proposed couplings. Provide required lengths as determined on the plans.

2. Channels shall be of equal length.

3. Refer to Section 27 15 00 for cable and connector performance requirements.

4. Basis of Design (Refer to 27 17 20 for Acceptable Manufacturers):

    a. Hubbell DFPC Series

B. Optical Fiber Patch Cords (Singlemode):

1. The optical fiber patch cord shall be 8.3/3 µm singlemode (SM) optical fiber, utilizing tight buffer construction. The optical fiber patch cords shall be a minimum of 5 feet (1.5m) in length.

2. Provide 8.3/3 µm singlemode (SM) optical fiber utilizing tight buffer construction for 50% of all assigned ports on the fiber distribution cabinet. These patch cords shall be the cross-connect between the backbone fiber distribution cabinet and the Owner's network electronics (hub/switch). Optical fiber patch cords shall be equipped with a ceramic tipped LC-type connector on each end and shall be a minimum of 5 feet (1.5m) in length. Connector body shall be of materials similar to that used in the proposed couplings. Provide required lengths as determined on the plans.

3. Channels shall be of equal length.

4. Refer to Section 27 15 00 for cable and connector performance requirements.

5. Basis of Design (Refer to 27 17 20 for Acceptable Manufacturers):

    a. Hubbell DFPC Series

PART 3 - EXECUTION

3.1 EQUIPMENT RACKS

A. Equipment racks shall be furnished and installed as shown on the drawings.

B. The Contractor shall bolt the rack to the floor as recommended by the manufacturer. Multiple racks shall be joined and the ground made common on each. The rack shall be stabilized by extending a brace to the wall. Alternately, overhead ladder rack by which the cabling accesses the equipment rack(s) may provide this function.

C. A space between the rack upright and the wall (approximately 4") should be provided to allow for cabling in that area. The rear of the rack should be approximately 40" from the wall to allow for access by maintenance personnel. In all cases, a minimum of 40" workspace in front of the rack is also required. Locations where these guidelines cannot be followed should be brought to the attention of the Architect/Engineer for resolution prior to installation.

D. All hardware and equipment is to be mounted between 18" and 79" above floor level. This is to afford easy access and, in the case of the lower limit, prevent damage to the components. Positioning of hardware should be reviewed and approved by the Architect/Engineer and Site Coordinator(s) prior to installation.

E. Equipment racks shall be equipped with cable management hardware as to allow an orderly and secure routing of optical fiber and/or copper cabling to the optical fiber distribution cabinets and/or modular patch panels. At minimum, one such horizontal jumper management panel shall be placed below each optical fiber distribution cabinet installed by the Contractor. Additional Jumper Management panels may be required pending installation of other cable types on the equipment rack.

F. Each rack shall be grounded to the Telecommunications Ground Bar (GND) using a #6 AWG (or larger) insulated stranded copper conductor (GREEN jacket) directly or via an adjacent grounded equipment rack. Refer to grounding requirements below.

3.2 LADDER RACK

A. Provide support for ladder rack on 4 ft centers.

B. Maintain a 1.5 safety factor on all load limits specified herein.

C. Ladder rack support shall be by 5/8” diameter threaded rod when ceiling mounted. Ladder rack requiring wall mounting shall utilize accessories supplied by the ladder rack manufacturer specifically for the purpose of wall mounting ladder rack.

3.3 D-RINGS

A. Provide D-rings for cable routing and management in all areas where open cabling is routed along the wall in an Equipment Room.

B. Locate D-rings on 24” centers vertically and horizontally.

C. Securely attach D-rings to the wall as required by the manufacturer.

3.4 GROUNDING

A. Provide a complete grounding system in accordance with the requirements of Section 27 05 26.

3.5 CROSS CONNECT INSTALLATION

A. Bend radius of cable shall not exceed 4 times the outside cable diameter or manufacturer’s recommendation, whichever is less.

B. Cables shall be neatly bundled and dressed to their respective panels and/or blocks. Each shall be fed by an individual bundle separated and dressed to the point of cable entrance into the rack and/or frame.

C. The cable jacket shall be maintained as close as possible to the termination point.

D. Each cable shall be clearly labeled on the cable jacket behind the patch panel at a location that is visible without removing the bundle support.

3.6 OPTICAL FIBER TERMINATION

A. All fiber slack shall be neatly coiled within fiber splice enclosures or splice trays. No slack loops shall be allowed external to the enclosure.

B. Each cable shall be individually attached to the respective fiber enclosure by mechanical means. The cable strength member shall be securely attached to the cable strain relief bracket in the enclosure.

C. Each cable shall be clearly labeled at the entrance to all enclosures.

D. A maximum of 12 strands shall be spliced in any tray.

3.7 CONDUITS AND CABLE ROUTING

A. Refer to Section 26 05 33 for additional requirements.

B. Where conduits enter a telecommunications room, conduits shall be terminated on the wall where shown on the contract documents. Conduits entering the room from the floor shall extend 3” above the floor slab.

C. Where cabling rises vertically in a telecommunications rooms, provide vertical cable management to support the cabling from floor to ceiling level.

D. All conduits shall be reamed and shall be installed with a nylon bushing.

E. Maintain appropriate conduit bend radius at all times. For conduits with an internal diameter of 2” or less, maintain a bend radius of at least 6 times the internal diameter. For conduits with an internal diameter greater than 2”, maintain a bend radius of at least 10 times the internal diameter.

END OF SECTION

SECTION 27 13 00

BACKBONE CABLING REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements relating to furnishing and installing backbone communications cabling and termination components and related subsystems as part of a cabling plant. The cabling plant consists of both optical fiber and/or copper cabling.

1.2 RELATED WORK

A. Section 27 05 00 – Basic Technology Systems Requirements.
B. Section 27 15 00 - Horizontal Cabling Requirements.
C. Section 27 17 20 - Support and Warranty.

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering all products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

2. Manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 The basis of design is listed herein. Refer to Section 27 17 20 for additional acceptable manufacturers**.**

2.2 OPTICAL FIBER BACKBONE – OUTSIDE PLANT

A. Duct Bank (Multimode/Singlemode):

1. This optical fiber cable shall be suitable for installation in underground duct and in innerduct.

2. Optical fiber cable materials shall be all dielectric (no conductive materials).

3. Optical fiber cable shall be filled with a water-blocking material.

4. Outer Sheath: Polyethylene (PE). The outer sheath shall be marked with the manufacturer's name, words identifying the cable type (e.g., "Optical Fiber Cable" or "Fiber Optic Cable"), year of manufacture, and sequential length markings. The actual length of the optical fiber cable shall be within -0/+1% of the length markings. The marking shall be in a contrasting color to the cable jacket.

5. Temperature Range:

   a. Storage: -40°C to +70°C (no irreversible change in attenuation).
   b. Operating: -40°C to +70°C.

6. Humidity Range: 0% to 100%.

7. Maximum Tensile Strength:

   a. During Installation: 2700 Newton (600 lb. force) (no irreversible change in attenuation).
   b. Long Term: 890 N (200 lb. force).

8. Bending Radius:

   a. During Installation: 20 times cable diameter.
   b. No Load: 10 times cable diameter.

B. Basis of Design (Multimode):

1. Corning (XXX).

C. Basis of Design (Singlemode):

1. Corning (XXX).

2.3 OPTICAL FIBER BACKBONE PERFORMANCE

A. OM3 Multimode (MM):

1. Fiber Type: Multimode; doped silica core surrounded by a concentric glass cladding.

2. Index Profile: Graded Index.

3. Transmission Windows: 850-nm and 1300-nm.

4. Core Diameter (nom): 50-ηm (microns) ± 2.5.

5. Cladding Diameter: 125-ηm ± 1.

6. Core-clad Concentricity: ≤ 1.0-ηm.

7. Cladding Non-circularity: ≤ 1.0%.

8. Fiber Coating Diameter:

   a. 245-ηm ± 10 (primary coating).
   b. 900-ηm (nominal) secondary coating (tight buffer)

c. All coatings shall be mechanically strippable without damaging the optical fiber.

9. Attenuation (maximum @ 23 ± 5°C; backbone):

a. @ 850-nm: 3.0 dB/km.
b. @ 1300-nm: 1.0 dB/km.
c. @1300-nm thru 1380-nm: 1.0dB/km

When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components," the average change in attenuation over the rated temperature range of the optical cable shall not exceed 0.50 dB/km with 80% of the measured fibers not exceeding 0.25 dB/km.

10. Bandwidth (minimum):

a. @ 850-nm: 2000 MHz*km.
b. @ 1300-nm: 500 MHz*km.

11. No optical fiber shall show a point discontinuity greater than 0.2 dB at the specified wavelengths. Such a discontinuity or any discontinuity showing a reflection at that point shall be cause for rejection of that optical fiber by the Owner.

B. Singlemode (SM):

1. Fiber Type: Singlemode; doped silica core surrounded by a concentric glass cladding.

2. Core Diameter: 8 to 9 µm. All optical fibers shall be of the same nominal core diameter and profile.

3. Cladding Diameter: 125 ± 1.0µm.

4. Cladding Non-circularity: ≤ 1%.

5. Core to Cladding Offset: ≤ 0.8 µm.

6. Fiber Coating Diameter:

a. 245 ± 15µm (primary coating).
b. 900-nm (nominal) secondary coating (tight buffer).
c. All coatings shall be mechanically strippable without damaging the optical fiber.

7. Cut-off Wavelength (cabled fiber; λ_{ccf}) ≤ 1260-nm.

8. Mode Field Diameter: 8.3 to 9.8 m at 1300-nm; 10.5 ± 1.0 µm at 1550-nm.

9. Zero Dispersion Wavelength (λ_0): 1301.5 nm ≤ l_0 ≤ 1321.5 nm.

10. Zero Dispersion Slope (S_0): ≤ 0.092 ps/nm^2*km.

11. Fiber Attenuation (maximum @ 23 ± 5°C; Backbone):

    a. @ 1300-nm: 2.0 dB/km
    b. @ 1550-nm: 1.75 dB/km

    When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components," the average change in attenuation over the rated temperature range of the optical fiber cable shall not exceed 0.05 dB/km at 1550-nm. The magnitude of the maximum attenuation change of each individual optical fiber shall not be greater than 0.15 dB/km at 1550-nm.

12. Fiber Dispersion (maximum):

    a. @ 1285 to 1330-nm: 3.2-ps/nm*km
    b. @ 1550-nm: 18-ps/nm*km

13. No optical fiber shall show a point discontinuity greater than 0.1 dB at the specified wavelengths. Such a discontinuity or any discontinuity showing a reflection at that point shall be cause for rejection of that optical fiber by the Owner.

PART 3 - EXECUTION

3.1 CABLE INSTALLATION REQUIREMENTS

A. Cable slack shall be provided in each backbone fiber optic cable. This slack is exclusive of the length of fiber that is required to accommodate termination requirements and is intended to provide for cable repair and/or equipment relocation. The <u>cable slack shall be stored</u> in a fashion as to protect it from damage and be secured in the termination enclosure or a separate enclosure designed for this purpose. Multiple cables may share a common enclosure.

B. A minimum of 5 meters (approximately 15 feet) of slack cable (each cable if applicable) shall be coiled and secured at both ends located in the entrance room, Telecommunications Room or main equipment room, for backbone and intra-building cable.

C. Where exposed, all backbone fiber optic cable shall be installed in protective inner duct. This includes areas where the cable is routed in cable tray and where making a transition between paths (e.g., between conduit and cable tray or into equipment racks). The inner duct should extend <u>into the termination and/or storage enclosure(s)</u> at system endpoints.

3.2 CROSS-CONNECTS

A. The Owner will be responsible for all cross-connects between the data backbone cabling and network electronics and between the data network electronics and horizontal cabling.

END OF SECTION

SECTION 27 15 00

HORIZONTAL CABLING REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements relating to furnishing and installing horizontal communications cabling and termination components and related subsystems as part of a cabling plant. The cabling plant consists of copper cabling.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards and plenum or non-plenum cable requirements.

B. The channel shall be required to meet the performance requirements indicated herein. The manufacturer shall warranty the performance of their system to the required performance (and not just to the Standard, should the required performance exceed the Standard).

C. Specific components of the channel shall be required, at a minimum, to meet the Standard component requirements for that particular component.

D. The installing contractor must be certified by the manufacturer of the structured cabling system.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering <u>all</u> products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

2. Manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 HORIZONTAL CABLE

A. CAT 6 Enhanced Cable:

1. The horizontal cable requirements must be met as well as the following channel requirements.

2. CAT 6 cable shall terminate on rack-mounted modular patch panels in their respective communication equipment room as indicated on the drawings.

3. Performance Tests shall be conducted using swept frequency testing through 250 MHz for the channel. All numbers given are for a 4-connection channel. Discrete frequency testing results at 250 MHz is not acceptable.

4. Performance data shall be characterized as "Guaranteed Headroom" and shall be warranted by the manufacturer to perform at guaranteed margins over ANSI/TIA/EIA-568-C.2. Performance data that is not warranted by the manufacturer will not be considered.

5. The structured cabling and connectivity must be provided by the same company. For the purpose of this specification that shall mean that the cabling and connectivity must be marketed, branded, supported, warranted, and distributed by the same company. Specifically, ally or partnerships between cabling manufacturers and connectivity manufacturers do not meet this requirement unless otherwise listed in Section 27 17 20 as an acceptable manufacturer. Specifically, products made by others through an OEM relationship are acceptable if the products are marketed, branded, supported, warranted, and distributed by the same company.

6. The 4-connector channel performance margins in the table below shall be guaranteed margins above ANSI/TIA/EIA-568-C.2:

Electrical Value (1 - 250 MHz)	**Minimum Margin**
Insertion Loss:	14.0%
NEXT:	7.0 dB
PS NEXT:	8.0 dB
ACR-F (ELFEXT):	8.0 dB
PS ACR-F (PS ELFEXT):	8.0 dB
Return Loss:	4.0 dB

7. The jacket color for CAT 6 cable shall be and blue for data applications.

8. Basis of Design:

    a. Hubbell C6ES
    b. Refer to Section 27 17 20 for additional acceptable manufacturers.

2.2 CONNECTORS/COUPLERS/ADAPTERS

A. Refer to Section 27 11 00 for requirements.

2.3 FACEPLATES/JACKS

A. CAT 6 Jacks:

1. CAT 6 horizontal cable shall each be terminated at their designated work area location on RJ-45 modular jacks. These modular jack assemblies shall snap into a modular mounting frame. The combined modular jack assembly is referred to as an information outlet.

2. The same orientation and positioning of modular jacks shall be utilized throughout the installation. Prior to installation, the Contractor shall submit the proposed configuration for each information outlet type for review by the Architect/Engineer.

3. Information outlet faceplates shall incorporate recessed designation strips at the top and bottom of the frame for identifying labels. Designation strips shall be fitted with clear plastic covers.

4. Where standalone CAT 6 only modular jacks are identified, the information outlet faceplate shall be configured as to allow for the addition of one (1) additional modular jack (CAT 3, CAT 5E, or CAT 6) to be installed to supplement each such modular jack as defined by this project. The installation of these supplemental modular jacks is NOT part of this project.

5. Any unused modular jack positions on an information outlet faceplate shall be fitted with a removable blank inserted into the opening.

6. The information outlet faceplate shall be constructed of high impact plastic (except where noted otherwise). The information outlet faceplate color shall (1) match the faceplate color used for other utilities in the building or (2) when installed in surface raceway (if applicable), match the color of that raceway.

7. Different faceplate and frame designs for locations, which include optical fiber cabling relative to those, that terminate only copper cabling are acceptable. Information outlets that incorporate optical fiber shall be compliant with the above requirements plus:

    a. Be a low-profile assembly.

    b. Incorporate a mechanism for storage of cable and fiber slack needed for termination.

    c. Position the optical fiber couplings to face downward or at a downward angle to prevent contamination.

    d. Incorporate a shroud that protects the optical fiber couplings from impact damage.

8. All information outlets and the associated modular jacks shall be of the same manufacturer throughout the project.

9. The CAT 6 modular jacks shall be non-keyed 8-pin modular jacks.

10. The interface between the modular jack and the horizontal cable shall be a 110-type termination block or insulation displacement type contact. Termination components shall be designed to maintain the horizontal cable's pair twists as closely as possible to the point of mechanical termination.

11. CAT 6 modular jacks shall be pinned per TIA-568A.

12. CAT 6 termination hardware shall, as a minimum, meet all the mechanical and electrical performance requirements of the following standards:

    a. ANSI/TIA/EIA-568-A-5
    b. ANSI/TIA/EIA-568A
    c. ISO/IEC 11801
    d. IEC 603-7
    e. FCC PART 68 SUBPART F

13. The color for CAT 6 jacks shall be blue for data applications. Alternately, a color-coded bezel or icon may be used to identify the CAT 6 modular jack.

2.4 COPPER WORK AREA CORDS

A. RJ-45:

1. Provide the same quantity of Category 6 copper work area cords as copper patch panel cords specified in Section 27 11 00. Copper work area cords shall be equipped with an 8-pin modular RJ-45 connector on each end.

2. Work area cords shall be 10’ in length.

3. Manufacturer of copper patch cable shall be the same as the manufacturer of the horizontal copper cable.

PART 3 - EXECUTION

3.1 CABLE INSTALLATION REQUIREMENTS

A. Horizontal Cabling:

1. The maximum horizontal cable drop length for Data UTP shall not exceed 295 feet (90 meters) in order to meet data communications performance specifications. This length is measured from the termination panel in the wiring closet to the outlet and must include any slack required for the installation and termination. The Contractor is responsible for installing horizontal cabling in a fashion so as to avoid unnecessarily long runs. Any area that cannot be reached within the above constraints should be identified and reported to the Architect/Engineer prior to installation. Changes to the contract documents shall be approved by the Architect/Engineer.

2. All cable shall be free of tension at both ends. In cases where the cable must bear some stress, Kellum grips may be used to spread the strain over a longer length of cable.

3. Manufacturer’s minimum bend radius specifications shall be observed in all instances.

4. Horizontal cabling installed as open cabling shall be supported at a maximum of 5’ between supports. Refer to the specifications for required cable supports.

5. Horizontal cabling installed as open cable or in cable tray shall be bundled at not less than 10' intervals with hook-and-loop tie wraps. The use of plastic cable ties is strictly prohibited.

6. The maximum conduit fill for horizontal cabling shall not exceed 40% regardless of conduit length.

7. Cable sheaths shall be protected from damage from sharp edges. Where a cable passes over a sharp edge, a bushing or grommet shall be used to protect the cable.

8. A coil of 3 feet in each cable shall be placed in the ceiling at the last support (e.g., J-hook, bridle ring, etc.) before the cables enter a fishable wall, conduit, surface raceway or box. At any location where cables are installed into movable partition walls or modular furniture via a service pole, approximately 15-feet of slack shall be left in each horizontal cable under 250 feet in length to allow for change in the office layout without re-cabling. These "service loops" shall be secured at the last cable support before the cable leaves the ceiling and shall be coiled from 100% to 200% of the cable recommended minimum bend radius.

9. To reduce or eliminate EMI, the following minimum separation distances from 480V power lines shall be adhered to:

   a. Twelve (12) inches from power lines of <5-kVa.
   b. Eighteen (18) inches from high-voltage lighting (including fluorescent).
   c. Thirty-nine (39) inches from power lines of 5-kVa or greater.
   d. Thirty-nine (39) inches from transformers and motors.

10. Information outlets shown on floor plans with the subscript "W" are intended to be used for wall mounted telephones. Back boxes for wall mounted telephones shall not be located within 12" vertically, or horizontally, from any light switches, power receptacles, nurse call devices, thermostats, or any other architectural element that would otherwise prevent the installation of a wall mounted telephone on the mating lugs.

B. Cable Terminations - Data UTP:

1. Modular patch panels shall be designed and installed in a fashion as to allow future horizontal cabling to be terminated on the panel without disruption to existing connections.

2. If the "last" patch (per rack) is greater than 50% utilized, one additional patch panel shall be provided for future use.

3. At information outlets and modular patch panels, the Contractor shall ensure that the twists in each cable pair are preserved to within 0.5-inch of the termination for data cables. The cable jacket shall be removed only to the extent required to make the termination.

END OF SECTION

SECTION 27 17 10

TESTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the testing requirements relating to the structured cabling system and its termination components and related subsystems.

1.2 RELATED WORK

A. Section 27 05 00 – Basic Communications Systems Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work, the Contractor shall submit:

1. Complete information on testing procedure as described herein.

2. Test plan summary for each cable type to be tested including equipment to be used, setup, test frequencies or wavelengths, results format, etc.

PART 2 - PRODUCTS

2.1 TESTING COPPER

A. General Requirements:

1. Perform acceptance tests as indicated below for each sub-system (e.g., backbone, horizontal, etc.) as it is completed.

2. Supply all equipment and personnel necessary to conduct the acceptance tests. The method of testing shall be approved by the Architect/Engineer.

3. Visually inspect all cabling and termination points to ensure that they are complete and conform to the wiring pattern defined herein. Provide the Architect/Engineer with a written certification that this inspection has been made.

4. Conduct acceptance testing according to a schedule coordinated with the Owner/Architect/Engineer. Representatives of the Owner may be in attendance to witness the test procedures. Provide a minimum of one (1) week's advance notice to the Architect/Engineer to allow for such participation. The notification shall include a written description of the proposed conduct of the tests, including copies of blank test result sheets to be used.

5. Tests related to connected equipment of others shall only be done with the permission and presence of the Contractor involved. The Contractor shall ascertain that testing only is required to prove the wiring connections are correct.

6. Provide test results and describe the conduct of the tests including the date of the tests, the equipment used, and the procedures followed. At the request of the Architect/Engineer, provide copies of the original test results in their native format.

7. All cabling shall be 100% fault-free unless noted otherwise. If any cable is found to be outside the specification defined herein, that cable and the associated termination(s) shall be replaced at the expense of the Contractor. The applicable tests shall then be repeated.

8. Should it be found by the Architect/Engineer that the materials or any portion thereof furnished and installed under this Contract fail to comply with the specifications and drawings with respect or regard to the quality, amount, or value of materials, appliances, or labor used in the work, it shall be rejected and replaced by the Contractor and all work disturbed by changes necessitated in consequence of said defects or imperfections shall be made good at the Contractor's expense.

    1) Horizontal Cable:

b. CAT 6 Cable:

    1) Testing shall be from the modular jack at the information outlet to the modular patch panel in the communication equipment room.

    2) Horizontal cable shall be free of shorts within the pairs, and be verified for continuity, pair validity and polarity, and conductor position on the modular jack (e.g., wire map). Any defective, split, or mis-positioned pairs must be identified and corrected.

    3) CAT 6 horizontal cable shall be tested to 250 MHz as defined by TIA/EIA-568-C.2. Measurements shall be of the "Basic Link" including cabling and modular jacks at the information outlet and modular patch panel. Parameters to be tested must include:

        a) Wire Map
        b) Length
        c) NEXT Loss (Pair-to-Pair)
        d) NEXT (Power Sum)
        e) ELFEXT (Pair-to-Pair)
        f) ELFEXT (Power Sum)
        g) Return Loss
        h) Attenuation
        i) Propagation Delay
        j) Delay Skew

4) The maximum length of horizontal cable shall not exceed 295 feet (90m), which allows 33 feet (10 m) for technology equipment and modular patch cords.

5) To establish testing baselines, cable samples of known length and of the cable type and lot installed shall be tested. The cable may be terminated with an eight-position CAT 6 modular connector (8-pin) to facilitate testing. Nominal Velocity of Propagation (NVP) and nominal attenuation values shall be calculated based on this test and be utilized during the testing of the installed cable plant. This requirement can be waived if NVP and nominal attenuation data is available from the cable manufacturer for the exact cable type under test.

6) CAT 6 horizontal cable testing shall be performed using a test instrument designed for testing to 250 MHz or higher. Test records shall verify, "PASS" on each cable and display the specified parameters, comparing test values with standards based "templates" integral to the unit. Test records that report a PASS*, FAIL*, or FAIL result for any of the parameters will not be accepted.

7) In the event results of the tests are not satisfactory, the Contractor shall make adjustments, replacements, and changes as necessary and shall then repeat the test or tests that disclosed faulty or defective material, equipment, or installation methods, and shall make additional tests as the Architect/Engineer deems necessary at no additional expense to the project or user agency.

2.2 TESTING FIBER

A. General Requirements:

1. Perform acceptance tests as indicated below for each optical fiber sub-system (e.g., backbone, horizontal, etc.) as it is completed.

2. Supply all equipment and personnel necessary to conduct the acceptance tests. The method of testing shall be approved by the Architect/Engineer.

3. Visually inspect all optical fiber cabling and termination points to ensure that they are complete and conform to the standards defined herein. Provide the Architect/Engineer with a written certification that this inspection has been made.

4. Conduct acceptance testing according to a schedule coordinated with the Owner/Architect/Engineer. Representatives of the Owner may be in attendance to witness the test procedures. Provide a minimum of one (1) week's advance notice to the Architect/Engineer to allow for such participation. The notification shall include a written description of the proposed conduct of the tests, including copies of blank test result sheets to be used.

5. Tests related to connected equipment of others shall only be done with the permission and presence of the Contractor involved. The Contractor shall ascertain that testing only is required to prove that the optical fiber connections are correct.

6. Provide test results and describe the conduct of the tests including the date of the tests, the equipment used and the procedures followed. At the request of the Architect/Engineer, provide copies of the original test results.

7. All optical fiber cabling shall be 100% fault-free unless noted otherwise. If any optical fiber cable is found to be outside the specification defined herein, that optical fiber cable and the associated connector(s) shall be replaced at the expense of the Contractor. The applicable tests shall then be repeated.

8. Should it be found by the Architect/Engineer that the materials or any portion thereof furnished and installed under this Contract fail to comply with the specifications and drawings with respect or regard to the quality, amount, or value of materials, appliances, or labor used in the work, it shall be rejected and replaced by the Contractor and all work disturbed by changes necessitated in consequence of said defects or imperfections shall be made good at the Contractor's expense.

9. The optical fibers utilized in the installed cable shall be traceable to the manufacturer. Upon request by the Owner, provide cable manufacturer’s test report for each reel of cable provided. These test reports shall include manufacturer’s on-reel attenuation test results at 850-nm and 1300-nm for each optical fiber of each reel prior to shipment from the manufacturer.

   a. On-the-reel bandwidth performance as tested at the factory. Factory data shall be provided upon request.

   b. The testing noted for optical fiber cabling utilizes an Optical Time Domain Reflectometer (OTDR). However, the Contractor may submit to the Architect/Engineer for pre-approval of alternate fiber optic testing equipment.

   c. Tests Prior to Installation:

      1) The Contractor, at their discretion and at no cost to the Owner, may perform an attenuation test with an OTDR at 850-nm or 1300-nm on each optical fiber of each cable reel prior to installation. Supply this test data to the Architect/Engineer prior to installation.

   d. Tests After Installation:

      1) Upon completion of cable installation and termination, the optical fiber cabling shall be tested to include:

         a) Optical Attenuation (“Insertion Loss” Method):

            (1) Optical Attenuation shall be measured on all terminated optical fibers in one direction of transmission using the “Insertion Loss” method

measurement in accordance with the TIA/EIA 526-14, Method B, and be inclusive of the optical connectors and couplings installed at the system endpoints. Access jumpers shall be used at both the transmit and receive ends to ensure that an accurate measurement of connector losses is made. Multimode optical fibers shall be tested at 850 ± 30 nm. Singlemode optical fibers (if applicable) shall be tested at 1300 ± 20 nm.7

(2) Attenuation of optical fibers shall not exceed the values calculated as follows:

Attenuation (max.) = 2*C+L*F+S dB

Where C is the maximum allowable Connector Loss (in dB), L is the length of the run (in kilometers), and F is the maximum allowable optical fiber loss (in dB/km). S is the total splice loss (# of splices * maximum attenuation per splice).

b) Verification of Link Integrity (OTDR):

(1) All optical fibers shall be documented in one direction of transmission using an Optical Time Domain Reflectometer (OTDR). Multimode optical fibers shall be tested at 850-nm and 1300-nm (nominal). Singlemode optical fibers (if applicable) shall be tested at 1310-nm and 1550-nm (nominal). The OTDR(s) shall incorporate high-resolution optics optimized for viewing of short cable sections. Access jumpers of adequate length to allow viewing of the entire length of the cable, including the connectors at the launch and receive end, shall be used. Access jumpers used for testing shall match the type and core diameter of the fiber optic strand under test.

(2) Set OTDR's test variables to the manufacturer's published backscatter coefficient and velocity of propagation figure for the specific strand of fiber under test. OTDR's range should be set to approximately 1.5 times the length of the strand under test, pulse width should be optimized for the length of the fiber optic strand under test, and number of averages should be adjusted to approximately 120 seconds per wavelength.

(3) OTDR traces revealing a point discontinuity greater than 0.2 dB in a multimode optical fiber or 0.1 dB in a singlemode optical fiber (if

applicable) at any of the tested wavelengths <u>or</u> any discontinuity showing a reflection at that point shall be a valid basis for rejection of that optical fiber by the Owner. The installation of that optical fiber cable shall be reviewed in an effort to remove any external stress that may be causing the fault. If such efforts do not remove the fault, that optical fiber cable and the associated terminations shall be replaced at the expense of the Contractor.

2.3 DOCUMENTATION/AS-BUILTS/RECORDS

A. General:

1. Upon completion of the installation, submit as-builts per the requirements of Section 27 05 00 and Division 1. Documentation shall include the items detailed in the subsections below.

2. All documentation, including hard copy and electronic forms, shall become the property of the Owner.

3. The Architect/Engineer may request that a 10% random field retest be conducted on the cable system at no additional cost to verify documented findings. Tests shall be a repeat of those defined above. If findings contradict the documentation submitted by the Contractor, additional testing can be requested to the extent determined necessary by the Architect/Engineer, including a 100% retest. This retest shall be at no additional cost to the Owner.

B. Copper Media Test Data:

1. Test results shall include a record of test frequencies, cable type, conductor pair and cable (or Outlet) I.D., measurement direction, test equipment type, model and serial number, date, reference setup, and crew member name(s).

2. Printouts generated for each cable by the wire test instrument shall be submitted as part of the documentation package. The Contractor shall furnish this information in electronic form (USB thumb drive). The thumb drive shall contain the electronic equivalent of the test results as defined by the bid specification and be in the tester's native format as well as summaries of each test in pdf format. Provide a licensed copy of the software required to view and print the data that is provided in a proprietary format. Furnish one (1) copy of the data and display (if applicable) software.

C. Optical Fiber Media Test Data:

1. Test results shall include a record of test wavelengths, cable type, fiber and cable (or Outlet) I.D., measurement direction, test equipment type, model and serial number, date, reference setup, and crew member name(s).

2. OTDR traces of individual optical fiber "signatures" obtained as specified above shall be provided to the Architect/Engineer in electronic form for review. Trace files shall be so named as to identify each individual optical fiber by location in the cable system and optical fiber number or color. Where traces are provided in

electronic form, provide along with the above documentation, one (1) licensed copy of software that will allow for the display of OTDR traces provided. The software shall run on a Microsoft Windows-based personal computer.

D. Record Drawings:

1. The drawings are to include cable routes and outlet locations. Outlet locations shall be identified by their sequential number as defined elsewhere in this document. Numbering, icons, and drawing conventions used shall be consistent throughout all documentation provided.

PART 3 - EXECUTION

NOT APPLICABLE

END OF SECTION

SECTION 27 17 20

SUPPORT AND WARRANTY

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes support and warranty requirements relating to the structured cabling system and related subsystems.

1.2 RELATED WORK

A. Section 27 05 00 – Basic Technology Systems Requirements.

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

PART 2 - PRODUCTS

2.1 MANUFACTURER REQUIREMENTS

A. The Basis of Design for all structured cabling components is listed in the individual Division 27 sections. Alternative acceptable manufacturers will not be accepted for this project.

1. Exceptions:

    a. Optical fiber.

B. Additional acceptable manufacturers for horizontal cabling:

1. Commscope
2. Hubbell/Mohawk
3. Panduit
4. Belden

C. Additional acceptable manufacturers for optical fiber:

1. Commscope

2. Panduit

3. Belden

2.2 WARRANTY

A. A twenty-five (25) year Product Installation Warranty and System Assurance Warranty shall be provided for the structured cabling system as described in the contract documents.

B. The Product Installation Warranty shall cover the replacement or repair of the defective product(s) and labor for the replacement or repair of such defective product(s).

C. The system assurance warranty shall cover the failure of the wiring system to support the application it was designed to support, as well as additional applications introduced in the future by recognized standards or user forums that use the TIA/EIA 568A component and link/channel specifications for cabling.

D. Upon successful completion of the installation and subsequent inspection, the Owner shall be provided with a numbered certificate from the manufacturing company registering the installation.

PART 3 - EXECUTION

NOT APPLICABLE

END OF SECTION

SECTION 28 05 00

BASIC ELECTRONIC SAFETY AND SECURITY SYSTEM REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Basic Safety and Security System Requirements (herein referred to Security) specifically applicable to Division 28 sections, in addition to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 REFERENCES

A. OSHPD - Office of State Wide Health Planning and Development (California)
B. CCR California Code of Regulation
C. CBC California Building Code
D. CFC California Fire Code
E. CEC California Electric Code
F. CMC California Mechanical Code
G. CPC California Plumbing Code
H. California Title 24 - Building Energy Efficiency Standards
I. SCAQMD Southern California Air Quality Management Division

1.3 SCOPE OF WORK

A. This Specification and the accompanying drawings govern the work involved in furnishing, installing, testing and placing into satisfactory operation the security systems as shown on the drawings and specified herein.

B. Each Contractor shall provide all new materials as indicated in the schedules on the drawings, and/or in these specifications, and all items required to make their portion of the security systems a finished and working system.

C. Description of systems include but are not limited to the following:

1. Electronic access control system

2. Electronic intrusion detection system

3. Video surveillance

4. Fire detection and alarm

5. Low voltage security wiring (less than +120VAC) as specified and required for proper system control and communications.

6. All associated electrical backboxes, conduit, miscellaneous cabling, and power supplies required for proper system installation and operation as defined in the "Suggested Matrix of Scope Responsibility".

7. Firestopping of penetrations of fire-rated construction as described in Specification Section 28 05 03 Division 7.

1.4 WORK SEQUENCE

A. All construction work that will produce excessive noise levels and interference with normal building operations, as determined by the Owner, shall be scheduled with the Owner. It may be necessary to schedule such work during non-occupied hours. The Owner shall reserve the right to set policy as to when restricted construction hours will be required.

B. Itemize all work and list associated hours and pay scale for each item.

1.5 DIVISION OF WORK BETWEEN ELECTRICAL AND SECURITY CONTRACTORS

A. Division of work is the responsibility of the Prime Contractor. Any scope of work described in the contract document shall be sufficient for including said requirement in the project. The Prime Contractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described in the contract documents. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Electrical Contractor" as referred to herein refers to the Contractors listed in Division 26 of this Specification.

2. “Electrical Contractor” shall also refer to the Contractor listed in Division 28 of this specification when the “Suggested Matrix of Scope Responsibility” indicates the work shall be provided by the EC. Refer to the Contract Documents for the “Suggested Matrix of Scope Responsibility”.

3. “Security Contractor” as referred to herein refers to the Contractors listed in Division 28 of this Specification.

4. Low Voltage Security Wiring: The wiring (less than 120VAC) associated with the Security Systems, used for analog and/or digital signals between equipment.

C. General:

1. The purpose of these Specifications is to outline typical Electrical and Security Contractor's work responsibilities as related to security systems including back boxes, conduit, cable tray, power wiring and low voltage security wiring. The prime contractor is responsible for all divisions of work.

2. The exact wiring requirements for much of the equipment cannot be determined until the systems have been purchased and submittals are approved. Therefore, only known wiring, conduits, raceways, and electrical power as related to such items, is shown on the Security Drawings. Other wiring, conduits, raceways, junction boxes, and electrical power not shown on the Security Drawings but required for the successful operation of the systems shall be the responsibility of the Security Contractor and included in the Contractor’s bid.

3. Where the Electrical Contractor is required to install conduit, conduit sleeves and/or power connections in support of Security systems, the final installation shall not begin until a coordination meeting between the Electrical Contractor and the Security Contractor has convened to determine the exact location and requirements of the installation.

4. Where the Electrical Contractor is required to install cable tray that will contain Low Voltage Security Wiring, the installation shall not begin until the Security Contractor has completed a coordination review of the cable tray shop drawing.

5. This Contractor shall establish Electrical and Security utility elevations prior to fabrication and installation. The Security Contractor shall cooperate with the Electrical Contractor and the determined elevations in accordance with the guidelines below. This Contractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

   a. Lighting Fixtures
   b. Gravity Flow Piping, including Steam and Condensate
   c. Sheet Metal
   d. Electrical Busduct
   e. Cable Trays, including 12” access space
   f. Sprinkler Piping and other Piping
   g. Conduit and Wireway
   h. Open Cabling

D. Electrical Contractor's Responsibility:

1. Assumes all responsibility for all required conduit and power connections when shown on the “Suggested Matrix of Scope Responsibility” to be provided by the Electrical Contractor.

2. Assumes all responsibility for providing and installing cable tray.

3. Responsible for Security Systems grounding and bonding.

4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

E. Security Contractor’s Responsibility:

1. Assumes all responsibility for the low voltage security wiring of all systems, including cable support where open cable is specified.

2. Assumes all responsibility for all required backboxes, conduit and power connections not specifically shown as being provided by the Electrical Contractor on the “Suggested Matrix of Scope Responsibility.”

3. Assumes all responsibility for providing and installing all ladder rack and other cable management hardware (as defined herein).

4. Responsible for providing the Electrical Contractor with the required grounding lugs or other hardware for each piece of security equipment which is required to be bonded to the telecommunications bonding system.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other contractors to determine a viable layout.

1.6 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

    a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.

    b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5” and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

    c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5” and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

    d. Maintenance clearances and code-required dedicated space shall be included.

    e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.

2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

    a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

   a. Scale of drawings:

      1) General plans: 1/4 Inch = 1 '-0" (minimum).

      2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).

      3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).

      4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1 '-0" (minimum).

      5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.

3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.

4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.

2. A plotted set of coordination drawings shall be available at the project site.

3. Coordination drawings are not shop drawings and shall not be submitted as such.

4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.

5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.

6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.

7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.

9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

    a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.

    b. Potential layout changes shall be made to avoid additional access panels.

    c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

    d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.

    e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain signoff of the drawings by all contractors prior to installing any of the components.

11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.

12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.7 QUALITY ASSURANCE

A. Qualifications:

1. Only products of reputable manufacturers as determined by the Architect/Engineer will be acceptable.

2. Each Contractor and their subcontractors shall employ only workers who are skilled in their respective trades and fully trained. All workers involved in the installation, termination, testing, and placing into operation electronic security devices shall be individually trained by the manufacturer.

3. The Contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size.

4. The Contractor shall own and maintain tools and equipment necessary for successful installation and testing of electronic security devices and have personnel adequately trained in the use of such tools and equipment.

5. A resume of qualification shall be submitted with the Contractor's bid indicating the following:

   a. A list of recently completed projects of similar type and size with contact names and telephone numbers for each.

B. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of Madison, Wisconsin's Codes, Laws, Ordinances and other regulations having jurisdiction.

2. In the event there are no local codes having jurisdiction over this job, the current issue of the National Electrical Code shall be followed.

3. If there is a discrepancy between the codes and regulations having jurisdiction over this installation, and these specifications, Architect/Engineer shall determine the method or equipment used.

4. If the Contractor notes, at the time of bidding, any parts of the drawings and specifications which are not in accordance with the applicable codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time to follow this procedure, he shall submit with the proposal, a separate price required to make the system shown on the drawings comply with the codes and regulations.

5. Verify the installation environment prior to purchasing or installing any cable. Cable installed in a plenum environment shall be appropriately rated. Bring all discrepancies between the contract documents and installation conditions to the attention of the Architect/Engineer prior to purchase or installation.

6. All changes to the system made after the letting of the contract, in order to comply with the applicable codes or the requirements of the Inspector, shall be made by the Contractor without cost to the Owner.

C. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all applicable laws, regulations, ordinances, and other rules of the State or Political Subdivision wherein the work is done, or as required by any duly constituted public authority.

3. Pay all applicable charges for such permits or licenses that may be required.

4. Pay all applicable fees and taxes imposed by the State, Municipal and/or other regulatory bodies.

5. Pay all charges arising out of required inspections due to codes, permits, licenses or as otherwise may be required by an authorized body.

6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized independent agency/consultant.

7. All equipment, and materials shall be as approved or listed by the following: (Unless approval or listing is not applicable to an item by all acceptable manufacturers.)

   a. Factory Mutual
   b. Underwriters' Laboratories, Inc.

D. Examination of Drawings:

1. The drawings for the Security Systems work are diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment etc., and the approximate sizes of equipment.

2. Contractor shall determine the exact locations of equipment and the exact routing of cabling to best fit the layout of the job. Scaling of the drawings will not be sufficient or accurate for determining this layout. Where a specific route is required, such route will be indicated on the drawings.

3. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

4. If an item is either shown on the drawings, called for in the specifications or required for proper operation of the system, it shall be considered sufficient for including same in this contract.

5. The determination of quantities of material and equipment required shall be made by the Contractor from the drawings. Schedules on the drawings and in the specifications are completed as an aid to the Contractor but where discrepancies arise, the greater number shall govern.

6. Where words "provide", "install", or "furnish" are used on the drawings or in the specifications, it shall be taken to mean, to furnish, install and terminate completely ready for operation, the items mentioned.

E. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed “Electronic File Transmittal” form provided by IMEG.

4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor's use of these documents.

F. Field Measurements:

1. Before ordering any materials, this Contractor shall verify all pertinent dimensions at the job site and be responsible for their accuracy.

1.8 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	**Submittal Item**
28 13 00	Electronic Access Control
28 23 00	Video Surveillance

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

a. Date
b. Project title and number
c. Contractor's name and address
d. Division of work (e.g., plumbing, heating, ventilating, etc.)
e. Description of items submitted and relevant specification number
f. Notations of deviations from the contract documents
g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

a. Date
b. Project title and number
c. Architect/Engineer

d. Contractor and subcontractors' names and addresses
e. Supplier and manufacturer's names and addresses
f. Division of work (e.g., plumbing, heating, ventilating, etc.)
g. Description of item submitted (using project nomenclature) and relevant specification number
h. Notations of deviations from the contract documents
i. Other pertinent data
j. Provide space for Contractor's review stamps

3. Composition:

a. Submittals shall be submitted using specification sections and the project nomenclature for each item.

b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).

c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

5. Contractor's Approval Stamp:

a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.

b. Unstamped submittals will be rejected.

c. The Contractor's review shall include, but not be limited to, verification of the following:

1) Only approved manufacturers are used.
2) Addenda items have been incorporated.
3) Catalog numbers and options match those specified.
4) Performance data matches that specified.
5) Electrical characteristics and loads match those specified.
6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
7) Dimensions and service clearances are suitable for the intended location.
8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.

9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.

e. **The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.**

6. Submittal Identification and Markings:

a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.

b. The Contractor shall clearly indicate the size, finish, material, etc.

c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.

d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.

8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.

9. Reproduction of contract documents alone is not acceptable for submittals.

10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.

11. Submittals not required by the contract documents may be returned without review.

12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.

13. Submittals shall be reviewed and approved by the Architect/Engineer **before** releasing any equipment for manufacture or shipment.

14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. Submittal file name: 28 XX XX.description.YYYYMMDD
   b. Transmittal file name: 28 XX XX.description.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be transmitted via a pre-approved method.

D. Paper Copy Submittal Procedures:

1. Paper copies are acceptable where electronic copies are not provided.

2. The Contractor shall submit ten (10) paper copies of each shop drawing.

3. Each set shall be bound in a three-ring binder or presentation binder. Copies that are loose or in pocket folders are not acceptable.

1.9 SCHEDULE OF VALUES

A. The requirements herein are in addition to the provisions of Division 1.

B. Format:

1. Use AIA Document Continuation Sheets G703 or another similar form approved by the Owner and Architect/Engineer.
2. Submit in Excel format.
3. Support values given with substantiating data.

C. Preparation:

1. Itemize work required by each specification section and list all providers. All work provided by subcontractors and major suppliers shall be listed on the Schedule of Values. List each subcontractor and supplier by company name.

2. Break down all costs into:

   a. Material: Delivered cost of product with taxes paid.
   b. Labor: Labor cost, excluding overhead and profit.

1.10 CHANGE ORDERS

A. A detailed material and labor takeoff shall be prepared for each change order, along with labor rates and markup percentages. Change orders with inadequate breakdown will be rejected.

B. Change order work shall not proceed until authorized.

1.11 EQUIPMENT SUPPLIERS' INSPECTION

A. The following equipment shall not be placed in operation until a representative of the manufacturer has inspected the installation and certified that the equipment is properly installed and that the equipment is ready for operation:

1. Firestopping, including mechanical firestop systems.

1.12 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to prevent damage to fixtures, equipment and materials.

B. Store materials on the site to prevent damage.

C. Keep fixtures, equipment and materials clean, dry and free from harmful conditions.

1.13 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.14 WARRANTY

A. At a minimum, provide a one (1) year warranty for all equipment, materials, and workmanship. Individual specifications sections within Division 28 may require additional warranty requirements for specific equipment or systems.

B. The warranty period for the entire installation described in this Division of the specifications shall commence on the date of substantial completion unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner or their representative.

C. Warranty requirements shall extend to correction, without cost to the final user, of all work and/or equipment found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from such defects or nonconformance with contract documents exclusive of repairs required as a result of improper maintenance or operation, or of normal wear as determined by the Architect/Engineer.

1.15 INSURANCE

A. This Contractor shall maintain insurance coverage as set forth in Division 1 of these specifications.

1.16 MATERIAL SUBSTITUTION

A. Where several manufacturers' names are given, the first named manufacturer constitutes the basis for job design and establishes the equipment quality required.

B. Equivalent equipment manufactured by the other named manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meets all requirements of the drawings and specifications and fits in the allocated space. The Architect/Engineer shall make the final determination of whether a product is equivalent.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer via addendum. The Contractor bears full responsibility for the unnamed manufacturers equipment adequately meeting the intent of design. The Architect/Engineer may reject manufacturer at time of shop drawing submittal. The Contractor assumes all costs incurred by other trades on the project as a result of changes necessary to accommodate the offered material, equipment or installation method.

D. Should this Contractor be unable to secure approval from the Architect/Engineer for other unnamed manufacturers as outlined above, this Contractor may list voluntary add or deduct prices for alternate materials on the bid form. These items will not be used in determining the low bidder. Should a voluntary alternate material be accepted, This Contractor shall assume all costs that may be incurred as a result of using the offered material, article or equipment necessitating extra expense on This Contractor or on the part of other Contractors whose work is affected.

PART 2 - PRODUCTS

2.1 REFER TO INDIVIDUAL SECTIONS

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or his or her employees and subconsultants at a construction site, shall relieve the Contractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Installation of all conduit and cabling shall comply with Sections 26 05 33 and 26 05 13. Additional conduit requirements described within this Division shall be supplemental to the requirement described in Section 26 05 33. Should conflicts exist between the two Divisions the more stringent (more expensive material and labor) condition shall prevail until bidding addendum or construction clarification or RFI can be submitted and responded to. In no case shall the Contractor carry the least stringent condition in the pricing.

B. It is the Contractor's responsibility to survey the site and include all necessary costs to perform the installation as specified.

C. The Contractor shall be responsible for identifying and reporting to the Architect/Engineer any existing conditions including but not limited to damage to walls, flooring, ceiling and furnishings prior to start of work. All damage to interior spaces caused by this Contractor shall be repaired at this Contractor's expense to pre-existing conditions, including final colors and finishes.

D. All cables and devices installed in damp or wet locations, including any underground or underslab location, shall be listed as suitable for use in such environments. Follow manufacturer's recommended installation practices for installing cables and devices in damp or wet locations. Any cable or device that fails as a result of being installed in a damp or wet location shall be replaced at the Contractor's expense.

3.3 FIELD QUALITY CONTROL

A. General:

1. Refer to specific Division 28 sections for further requirements.

2. The Contractor shall conduct all tests required and applicable to the work both during and after construction of the work.

3. The necessary instruments and materials required to conduct or make the tests shall be supplied by the Contractor who shall also supply competent personnel for making the tests who has been schooled in the proper testing techniques.

4. In the event the results obtained in the tests are not satisfactory, This Contractor shall make such adjustments, replacements and changes as are necessary and shall then repeat the test or tests which disclose faulty or defective work or equipment, and shall make such additional tests as the Architect/Engineer or code enforcing agency deems necessary.

B. Protection of cable from foreign materials:

1. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.

2. Application of foreign materials of any kind on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

3.4 PROJECT CLOSEOUT

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. The Architect/Engineer will not perform a final jobsite observation until the project is ready. This is not dictated by schedule, but rather by completeness of the project.

2. Refer to the end of Section 27 05 00 for a "STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION."

3. The Contractor shall sign this form and return it to the Architect/Engineer so that the final observation can commence.

C. Before final payment will be authorized, this Contractor must have completed the following:

1. Submitted operation and maintenance manuals to the Architect/Engineer for review.

2. Submitted bound copies of approved shop drawings.

3. Record documents including edited drawings and specifications accurately reflecting field conditions, **<u>inclusive</u>** of all project revisions, change orders, and modifications.

4. Submitted a report stating the instructions given to the Owner's representative complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representative as having received the instructions.

5. Submitted testing reports for all systems requiring final testing as described herein.

6. Submitted start-up reports on all equipment requiring a factory installation inspection and/or start.

7. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site insert address here; submit receipt to Architect/Engineer prior to final payment being approved.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.

2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. O&M file name: O&M.div28.contractor.YYYYMMDD
   b. Transmittal file name: O&Mtransmittal.div28.contractor.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be divided into files that are clearly labeled as "1 of 2", "2 of 2", etc.

6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.

7. All text shall be searchable.

8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Paper Copy Submittal Procedures:

1. Once the electronic version of the manuals has been approved by the Architect/Engineer, ______ paper copies of the O&M manual shall be provided to the Owner. The content of the paper copies shall be identical to the corrected electronic copy.

2. Binder Requirements: The Contractor shall submit O&M manuals in heavy duty, locking three ring binders. Incorporate clear vinyl sheet sleeves on the front cover and spine for slip-in labeling. "Peel and stick" labels are **not** acceptable. Sheet lifters shall be supplied at the front of each notebook. The three-ring binders shall be 1/2"12mm thicker than initial material to allow for future inserts. If more than one notebook is required, label in consecutive order. For example; 1 of 2, 2 of 2. No other form of binding is acceptable.

3. Binder Labels: Label the front and spine of each binder with "Operation and Maintenance Instructions", title of project, and subject matter.

4. Index Tabs: Divide information by specification section, major equipment, or systems using index tabs. All tab titling shall be clearly printed under reinforced plastic tabs. All equipment shall be labeled to match the identification in the construction documents.

D. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.

2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.

3. Copies of all final approved shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.

4. Copy of final approved test and balance reports.

5. Copies of all factory inspections and/or equipment startup reports.

6. Copies of warranties.

7. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.

8. Dimensional drawings of equipment.

9. Capacities and utility consumption of equipment.

10. Detailed parts lists with lists of suppliers.

11. Operating procedures for each system.

12. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.

13. Repair procedures for major components.

14. List of lubricants in all equipment and recommended frequency of lubrication.

15. Instruction books, cards, and manuals furnished with the equipment.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVE

A. Adequately instruct the Owner's designated representative or representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representative or representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. Contractor shall make a DVD video recording of instructions to the Owner while explaining the system so additional personnel may view the instructions at a later date. The video recording shall be the property of the Owner.

[* * * * * O R * * * * *]

D. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

E. The Architect/Engineer shall be notified of the time and place for the verbal instructions to be given to the Owner's representative so that their representative can be present if desirable.

F. Refer to the individual specification sections for minimum hours of instruction time for each system.

G. Operating Instructions:

1. The Contractor is responsible for all instructions to the Owner and/or Owner's operating staff on the security systems.

2. If the Contractor does not have Engineers and/or Technicians on staff that can adequately provide the required instructions on system operation, performance, troubleshooting, care and maintenance, they shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 SYSTEM COMMISSIONING

A. The security systems included in the construction documents are to be complete and operating systems. The Architect/Engineer will make periodic job site observations during the construction period. The system start-up, testing, configuration, and satisfactory system performance is the responsibility of the Contractor. This shall include all calibration and adjustments of electrical equipment controls, equipment settings, software configuration, troubleshooting and verification of software, and final adjustments that may be required.

B. All operating conditions and control sequences shall be simulated and tested during the start-up period.

C. The Contractor, subcontractors, and equipment suppliers are expected to have skilled technicians to ensure that the system performs as designed. If the Architect/Engineer is requested to visit the job site for the purpose of trouble shooting, assisting in the satisfactory start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period through no fault of the design; the Contractor shall reimburse the Owner on a time and material basis for services rendered at the Architect/Engineer's standard hourly rates in effect at the time the services are requested. The Contractor shall be responsible for making payment to the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.8 RECORD DOCUMENTS

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Mark specifications to indicate approved substitutions, change orders, and actual equipment and materials used.

C. This Contractor shall maintain at the job site, a separate and complete set of Security Drawings which shall be clearly and permanently marked and noted in complete detail any changes made to the location and arrangement of equipment or made to the Technology Systems and wiring as a result of building construction conditions or as a result of instructions from the Architect or Engineer. <u>All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents</u>. Record documents that merely reference the existence of the above items are not acceptable. Should This Contractor fail to complete Record Documents as required by this contract, This Contractor shall reimburse Architect/Engineer for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at the Architect/Engineer’s hourly rates in effect at the time of work.

D. Record actual routing of all conduits sized 2” or larger.

E. The above record of changes shall be made available for the Architect and Engineer's examination during any regular work time.

F. Upon completion of the job, and before final payment is made, This Contractor shall give the marked-up drawings to the Architect/Engineer.

3.9 ADJUST AND CLEAN

A. Contractor shall thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project.

B. Contractor shall clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from equipment.

C. Contractor shall remove all rubbish, debris, etc., accumulated during the Contractor's operations from the premises.

3.10 SPECIAL REQUIREMENTS

A. In accordance with LEED EQc4.1, Low-Emitting Materials - Adhesives and Sealants, all adhesives and sealants used on the interior of the building must comply with the following requirements:

1. Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168.

2. Aerosol adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000.

3.11 CONSTRUCTION WASTE MANAGEMENT

A. This Contractor shall comply with all construction and demolition waste disposal and recycling requirements outlined in LEED MRc2: Construction Waste Management (follow latest edition at the time of bidding or as referenced in these specifications).

1. This Contractor shall coordinate with the General Contractor Construction Manager to develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on-site or co-mingled.

2. The Contractor shall track waste disposal and recycling efforts throughout the construction process for all materials associated with this Contractor's scope of work. The Contractor shall provide this information to the General Contractor Construction Manager so that it can be incorporated with similar information from all other contractors for the project.

   a. Calculations for waste and recycled material can be done by weight or volume, but they must be consistent throughout the project. The Contractor shall coordinate with the General Contractor Construction Manager to establish the preferred calculation method and report the results accordingly.

   b. Excavated soil and land-clearing debris do not count towards the waste disposal or recycled material.

3. At a minimum, 50% 75% of the construction and demolition debris for this project must be recycled or salvaged.

END OF SECTION

SECTION 28 13 00

ELECTRONIC ACCESS CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Server
B. Client Workstations
C. Field Control Hardware
D. Application Software
E. Access Control Graphical User Interface
F. Credentials and Badging
G. Portal Devices

1.2 RELATED WORK

A. Section 08 71 00 – Door Hardware
B. Section 26 05 13 – Wire and Cable
C. Section 26 05 33 – Conduits and Boxes
D. Section 27 05 26 – Communications Bonding
E. Section 27 05 28 – Interior Communication Pathways
F. Section 27 05 43 – Exterior Communication Pathways
G. Section 27 05 53 – Identification and Administration
H. Section 27 15 00 - Horizontal Cabling Requirements
I. Section 28 05 00 – Basic Electronic Safety and Security System Requirements.
J. Section 28 23 00 – Video Surveillance
K. Section 28 31 00 - Fire Detection and Alarm Systems.

1.3 QUALITY ASSURANCE

A. Manufacturer: The manufacturer shall have a minimum of ten (10) years documented experience in the development and manufacture of access control software and hardware. The software developer shall be, at a minimum, a Microsoft Silver Certified Integrator and Partner for those systems that reside in a Microsoft environment.

B. Contractor:

1. Shall be a factory-authorized installation, service and support company specializing in the selected manufacturer's product, with demonstrated prior experience of a minimum of ten (10) years installing, programming and supporting the selected manufacturer's system.

2. Shall have been in business for a minimum of ten (10) years and shall have installed a minimum of three (3) similar or larger sized systems. Contractor shall have a minimum of two (2) service technicians who are certified in the proposed manufacturer's system.

3. Shall have as a regular, full time employee a minimum of one employee with the following certification(s) or education Should more than one certification be required, one employee may maintain multiple certifications.

a. A certification of RCDD from BICSI or CNIDP from CNet.

C. Material:

1. All material which is Contractor furnished shall be new, unused and free from defects.

2. Where more than one of any specified item of equipment or material is used, all such items shall be the same product from the same manufacturer.

1.4 REFERENCES

A. International Building Code
B. NFPA 70 - National Electrical Code.
C. The BOCA National Building Code
D. UL 294 - Standard for Access Control Systems.
E. UL 365 – Standard for Police Station Connected Burglar Alarm Units and Systems.
F. UL 464 – Standard for Audible Signal Appliances.
G. UL 603 – Standard for Power Supplies for Use with Burglar Alarm Systems.
H. UL 609 - Standard for Local Burglar Alarm Units and Systems
I. UL 634 – Standard for Connectors and Switches for Use with Burglar Alarm Systems.
J. UL 827 – Standard for Central Station Alarm Services.
K. UL 1076 – Standard for Proprietary Burglar Alarm Units and Systems.
L. UL 1449 – Standard for Surge Protective Devices.
M. UL 1635 – Standard for Digital Alarm Communicator Systems.
N. UL 1638 – Standard for Visual Signaling Appliances – Private Mode Emergency and General Utility Signaling.
O. UL 1778 – Uninterruptible Power Systems.

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 28 05 00.

B. Product Data Submittal: Provide manufacturer's technical product specification sheet for each individual component type. Submitted data shall show the following:

1. Compliance with each requirement of these documents. The submittal shall acknowledge each requirement of this section, item-by-item.

2. All component options and accessories specific to this project.

3. Electrical power consumption rating and voltage.

4. Heat generation for all power consuming devices.

5. Wiring requirements.

6. Server processor(s), workstation configurations, total and available disk space, and memory size.

7. All network bandwidth, latency and reliability requirements.

8. Backup/archive system size and configuration.

9. Submit two of each type of credential to be used (access card, key fob, etc.).

C. System Drawings: Project-specific system CAD drawings shall be provided as follows:

1. Provide a system block diagram noting system components and interconnection between components. The interconnection of components shall clearly indicate all wiring required in the system. When multiple pieces of equipment are required in the exact same configuration (e.g., multiple identical controllers), the diagram may show one device and refer to the others as “typical” of the device shown. The diagram shall list room numbers where each controller will be located. This block diagram shall be provided in Adobe PDF.

2. Provide a schedule of all controllers and the doors/points each controller controls. This schedule shall be provided in Adobe PDF.

3. Provide schedules describing each system input location by an architecturally familiar reference, e.g., Door 312A. The architectural door schedule shall be used as the basis. These schedules shall be provided in Adobe PDF

D. Submit sample format of site specific programming guides to be used for system planning/programming conference with Owner. These guides shall be provided in Adobe PDF.

E. So that required Owner personnel are present at the planning/programming conference required in Part 3 of this section, submit meeting agenda for the conference a minimum of two weeks prior to the conference.

F. Submit detailed description of Owner training to be conducted at project end, including specific training times. Refer to Part 3 of this section for details.

G. IP Addresses: Contractor shall provide to Owner, in a documented transmittal and in Microsoft Excel format, the names and locations of devices which require an IP address. An authorized representative of the Owner shall furnish the addresses for the associated devices in Microsoft Excel format in a documented transmittal. Should Owner change the IP address structure after approval of the list, Owner may be responsible for additional fees involved with reprogramming.

H. Quality Assurance:

1. Provide materials documenting experience requirements of the manufacturer and Installing Contractor. Provide documentation of the training and other applicable certifications of the Contractor.

2. Provide system checkout test procedure to be performed at acceptance. Test procedures shall include all external alarm events.

1.6 SYSTEM DESCRIPTION

A. This section describes the furnishing, installation, programming and commissioning of a complete, turnkey access control system. The terms “access control system” and “security management system”, or SMS, may be used interchangeably herein.

B. The company, manufacturer, and product names used in this section are for identification purposes only. All trademarks and registered trademarks are the property of their respective owners.

C. Performance Statement: This section and the accompanying access control-specific design documents are performance based, describing the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the equipment constraints described and the performance required of the system, as presented in these documents, the vendor and the Contractor are solely responsible for determining all wiring, programming, and miscellaneous equipment required. The Contractor shall be responsible for determining quantities of materials required for a complete and operational system. Floor plan drawings and schedules have been developed to aid the Contractor in determining device quantities and installation locations, but, where discrepancies between floor plans and schedules arise, the greater number shall govern.

D. Basic System Description:

1. The access control system shall provide the following functionality:

a. Electronic control access to designated areas.

b. Validation of cardholder credentials by use of personnel database, card formats. The system shall compare the time, location, and unique credentials of an attempted entry with information stored in the database.

c. Access to designated areas will be validated only when a user's credential has a valid number for its facility and the number is valid for the current time and for the reader where it is used.

d. The system software shall access the hardware that validates the person and monitors the security of a building by use of intelligent system controllers, reader interfaces, locks, readers, inputs and outputs. When access has been validated, a signal to the portal locking device shall be activated to enable alarm free access at that location.

e. The system shall be configured by use of application software.

f. The system shall monitor activities using operator monitoring software which includes graphical maps which display alarms, status and activity.

g. The system shall differentiate and restrict administrative and operational access through use of password authentication.

h. The system shall report on various aspects of the system by use of reports, both default and customizable. Reports shall be able to be printed.

i. The system shall have the capability to report alarms both audibly and visually.

j. The system shall control hardware from the monitoring station by use of manual actions and events.

k. The system shall provide record and data management by use of journals. There shall be a full audit trail.

l. The system shall allow for data to be imported from other products by use of database migration tools. These products may include Human Resources databases for name and/or time and attendance information, information from previous access control systems consisting of badge numbers from credentials that will be re-used, Microsoft Excel spreadsheets, or other systems as defined herein.

m. The system shall allow access using a web interface or a mobile application for use on the iOS and Android operating systems.

E. Integrations, Software Development Kit (SDK) and Application Programming Interface (API):

1. The manufacturers of the systems that are integrated shall make an SDK available to other manufacturers.

2. Prior to the release of this section, the manufacturers of the systems that are to be integrated shall have made available to each other all APIs to perform the specific integrated functions required in this section.

3. The integrations shall be completed and tested, and shall have been implemented on at least one system of similar size prior to the release of this section. The integrations shall not be accomplished for the first time for this project unless written pre-approval has been granted by Owner to Contractor prior to bid deadline.

4. During the warranty period, should a new API or version of software be released by the SMS manufacturer or any of the manufacturers of systems or devices that are integrated, that API or version of software shall be installed in the appropriate system or device defined in this section at no charge to Owner. Should any loss of functionality in the integration be exposed through this installation, as compared to the accepted system, Contractor shall correct the functionality at no charge to Owner.

5. Any and all development costs for specified functionality or inter-system integrations shall be included in the Contractor's bid. No additional costs or fees for the integrations shall be charged to Owner from the time of notice to proceed through system acceptance.

1.7 OWNER FURNISHED MATERIAL

A. Telephone service
B. Data circuit / internet service
C. Active telephone service equipment, such as key system, PBX or VOIP switch equipment
D. Active computer network equipment:

1. Routers
2. Servers
3. Switches
4. Hubs

5. Wireless access points
6. Uninterruptible power supplies <u>for Owner furnished products</u>

E. Active computer equipment:

1. SMS server – refer to Part 2 for details
2. SMS workstation(s) – refer to Part 2 for details
3. Uninterruptible power supplies for Owner furnished products

F. Credentials:

1. RFID Tags

1.8 LICENSING REQUIREMENTS

A. All user licenses required for system operation shall be included in the Contractor's bid. User licenses shall include server and workstation software, network controllers, card readers, printers, badging stations, and any other licensing that is required by the manufacturer for operation of any system component.

1. Licenses shall be provided on a one-to-one basis. One license shall be provided for each device requiring a license. In the event the manufacturer requires the purchase of a block of licenses, license blocks provided shall be no greater than what is required for the number of devices in this project. Contractor shall document the number of remaining licenses in the project record documents and Operations and Maintenance data.

2. In addition to the licensing requirements listed above, provide licensing and configuration of system administration/operation software for 2 workstations. The workstation licenses shall be concurrent use seats, and the client software shall be able to be loaded on an unlimited number of workstations at no extra cost to the Owner. Contractor shall install client software on the same number of machines as licenses provided. As part of the training, Contractor shall demonstrate to Owner how to install client software on additional workstations.

3. All Contractor-furnished software shall contain a perpetual, permanent license in which no other fees beyond the single payment for the work of this section are required in order to use the proposed software indefinitely. Owner understands that, after the initial warranty period has expired, maintenance and technical support fees may be required annually, quarterly, or monthly in order to receive software updates and technical support. However, it remains the option of Owner to purchase or decline this service. If Owner chooses to discontinue or never purchase this service, the software shall continue to be legally licensed for use. All software shall be the latest version released, and all Contractor-furnished servers and workstations shall be current on all patches and updates for all software on the machines at the time of acceptance of the associated systems.

4. The SMS shall require only a single license key present on the server for the SMS to operate. The key shall be a physical device or a software key. License keys shall not be required at the client workstations.

1.9 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 28 05 00.

B. Provide final system block diagram showing any deviations from shop drawing submittal.

C. Provide statement that system checkout test, as outlined in the shop drawing submittal, is complete and satisfactory.

D. Provide schedules documenting:

1. Controller installation locations including specific door numbers being controlled.
2. All terminal block wiring, including cable numbers.

E. Warranty: Submit written warranty and complete all Owner registration forms.

F. Complete all operation and maintenance data manuals as described below.

1.10 OPERATION AND MAINTENANCE DATA

A. Submit documents under the provisions of Section 28 05 00.

B. Manuals: Final copies of the manuals shall be delivered within 30 days after completing the installation test. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of the contractor responsible for the installation and maintenance of the system, and the factory representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The final copies delivered after completion of the installation test shall include all modifications made during installation, checkout, and acceptance testing. Manuals shall be submitted in electronic format only, Adobe PDF. The manuals shall consist of the following:

1. Hardware Manual: The manual shall describe all equipment furnished including:

    a. General description and specifications.
    b. Installation and check out procedures.
    c. System and equipment layout and electrical schematics to the control board and field device level. For multiple devices wired identically, only one wiring diagram is required per door configuration, to be labeled "TYPICAL".
    d. Alignment and calibration procedures.
    e. Manufacturers repair parts list indicating sources of supply.

2. Software Manual: The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

    a. Definition of terms and functions.
    b. System use and application software.
    c. Initializations, startup, and shutdown procedures.
    d. Reports generation.
    e. Details on forms customization and field parameters.

3. Operator's Manual: The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

    a. Computers and peripherals.
    b. Log in/Log out procedures.

c. Use of system, command, and applications software.
d. Recovery and restart procedures.
e. Graphic alarm presentation.
f. Use of report generator and generation of reports.
g. Data entry.
h. Operator commands.
i. Alarm messages.
j. System permissions functions and requirements.

4. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection, cleaning, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.11 WARRANTY

A. Unless otherwise noted, provide warranty for one (1) year after date of Substantial Completion for all materials and labor.

B. Onsite Work During Warranty Period: This work shall be included in the Contractor’s bid and performed during regular working hours, Monday through Friday.

1. Inspections: The Contractor shall perform two minor inspections at six-month intervals (or more often if required by the manufacturer), and two major inspections offset equally between the minor inspections to effect quarterly inspection of alternating magnitude.

2. Minor Inspections: These inspections shall include:

a. Visual checks and operational tests of all equipment, field hardware, and electrical and mechanical controls.
b. Mechanical adjustments if required on any mechanical or electromechanical devices.

3. Major Inspections: These inspections shall include all work described under paragraph Minor Inspections and the following work:

a. Clean all equipment, including exterior surfaces and accessible and serviceable interior surfaces.
b. Perform diagnostics on all equipment.
c. Check, test, and calibrate (if required) all sensors.
d. Run all system software diagnostics and correct all diagnosed problems.

C. Operation: Upon the completion of any scheduled adjustments or repairs, Contractor shall verify operation of the SMS.

D. Service: The Owner will initiate service calls when the SMS is not functioning properly. If requested by the Owner, the Contractor shall respond or remain at the site after normal business hours, and the Owner shall reimburse the Contractor for the incremental cost difference between premium labor rates and standard labor rates. This reimbursement applies to premium labor rates that do not exceed time-and-one-half rates after normal business hours and double-time rates for Sundays and holidays. The Owner shall be furnished with telephone number(s) where service personnel can be reached 24/7/365. Qualified service personnel shall be at the site within 24 hours after receiving a request for service.

E. Records, Logs and Work Requests: Contractor shall keep records and logs of each task completed under and outside of warranty. These logs shall be maintained in Microsoft Word or Excel. The log shall include the model and serial number identifying the component involved, its location, date and time the call was received, specific nature of trouble, names of service personnel assigned to the task, description of work performed, the amount and nature of the material used, and the time and date of commencement and completion of the work. Complete logs shall be kept and shall be available for review on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the SMS. The Contractor shall deliver a record of the work performed within three (3) business days after work is completed. Defective items that have been replaced shall be given to the Owner. Should the replacement item be a temporary replacement until the removed item is repaired, Contractor shall retain possession of the defective item for repair and subsequent re-installation.

F. System Modifications: Modifications by the Contractor are allowed after system acceptance. Contractor shall make recommendations for system modification in writing to the Owner. No system modifications shall be made without prior, written approval of the Owner. Any modifications made to the system shall be incorporated into the Operations and Maintenance Manuals, and other documentation affected. The Owner shall be provided with electronic restorable versions of all configurations prior to the modifications being made.

G. Software: At no charge, the Contractor shall provide to Owner all updates released by the manufacturer during the period of the warranty and verify operation of the system upon installation. These updates include system software updates, patches, bug fixes and revisions, as well as firmware updates. These updates shall be accomplished in a timely manner, fully coordinated with SMS administrators and operators, shall include training for the new changes/features, and shall be incorporated into the Operations and Maintenance Manuals and software documentation.

H. Refer to the individual product sections for further warranty requirements of individual system components.

1.12 ANNUAL SERVICE CONTRACT

A. Provide annual cost for extended service and maintenance agreement after the first year for the access control system according to the following terms:

1. The term of the warranty shall begin on the system acceptance date and shall continue for one (1) year. The extended service and maintenance warranty shall begin following this first year if accepted by the Owner. The term shall be automatically renewed for successive one-year periods unless canceled in writing by the Owner with Contractor confirmed receipt, up to the date of expiration. The service and maintenance agreement shall include the following basic services to the Owner, including all necessary parts, labor and service equipment:

a. Repair or replace any security equipment item that fails to perform as initially installed, as specified, or as determined per the manufacturer's performance criteria.

b. Perform preventive maintenance on the security equipment during the 6th month and 12th month of the service contract. This preventive maintenance shall include cleaning, realignment, inspection, and testing of security devices. The Owner shall receive a written report of these inspections that identifies the security system's status and, if required, a list of all necessary repairs or replacements.

c. Provide maintenance on the SMS system software. At no charge, the Contractor shall provide to Owner all updates released by the manufacturer during the period of the service contract and verify operation of the system upon installation. These updates include system software updates, patches, bug fixes and revisions, as well as firmware updates. These updates shall be accomplished in a timely manner, fully coordinated with SMS administrators and operators, shall include training for the new changes/features, and shall be incorporated into the Operations and Maintenance Manuals and software documentation. Contractor shall not be responsible for maintenance of Owner data.

2. The Contractor shall be compensated for any repairs or maintenance provided as a result of Owner abuse, misuse, intentional damage, accidental damage, or power fluctuations exceeding specified equipment tolerances.

3. Service: The Owner will initiate service calls when the SMS is not functioning properly. If requested by the Owner, the Contractor shall respond or remain at the site after normal business hours, and the Owner shall reimburse the Contractor for the incremental cost difference between premium labor rates and standard labor rates. This reimbursement applies to premium labor rates that do not exceed time-and-one-half rates after normal business hours and double-time rates for Sundays and holidays. The Owner shall be furnished with telephone number(s) where service personnel can be reached 24/7/365. Qualified service personnel shall be at the site within 24 hours after receiving a request for service.

B. Provide complete terms and conditions of warranty and service.

C. The Owner will enter into a contract directly with the vendor. This specification section is not a contract between the Owner and the vendor to perform these services.

PART 2 - PRODUCTS

2.1 ELECTRONIC ACCESS CONTROL SYSTEM MANUFACTURERS

A. Genetec Synergis
B. Lenel OnGuard
C. AXIS
D. S2 Extreme/Enterprise

E. Should the access control manufacturer offer, as an option, the use of hardware by Mercury Security, the Contractor proposed solution shall utilize this hardware. Contractor shall state whether or not the software is compatible with the SCP, AP and EP families of Mercury Security hardware. For future additions or defective hardware replacements, the system shall not be "locked" to require Mercury Security hardware be purchased only from the access control software manufacturer or from the original Installing Contractor.

F. Approval of Alternate Manufacturers:

1. Contractors seeking approval for alternate manufacturers for any devices or software in this section shall submit requests for approved equals as defined by Division 1 in addition to submitting:

a. Bill of materials for each piece of hardware and software proposed.

b. Manufacturer's data sheet for each piece of equipment proposed.

c. Line-by-line typewritten statement of compliance or non-compliance comparing Part 2 of this section with the published specifications of the proposed alternate products. This compliance statement shall be signed by an officer of the local contractor branch office that proposes to install the alternate product and either an officer of the manufacturer or an officer of the manufacturer's representative.

2. Refer to the project drawings for manufacturer and model numbers for the Basis of Design products.

2.2 SERVER

A. The system shall not be required to have a traditional or virtual server and, instead, may be provided with embedded server functionality integral to the controller if the following three (3) conditions are met. The server specified below shall apply if the system does not meet these three (3) conditions:

1. The network controller is a distributed architecture, native IP network appliance.

2. The network appliance contains an onboard, embedded operating system (e.g., Linux-based), web server, ODBC-compliant database engine, data storage device and application logic controller.

3. The network appliance contains onboard SSL communications.

B. If the system architecture utilizes traditional servers, the system shall be a true multi-tasking, multi-threading application system architecture designed specifically for the Windows environment. All modules, including access control, alarm monitoring, credential management, etc., shall be built from a single unified 32-bit source code set.

C. The system shall communicate on a TCP/IP based Ethernet LAN capable of utilizing 10/100/1000 BaseT.

D. The system shall be functional in a virtual server environment.

E. Provisioning:

1. The server shall be furnished by the Owner and shall meet the specifications defined by the SMS software manufacturer to meet or exceed the functionality and performance specifications of the system and integrations defined in this and related sections. Contractor shall furnish specifications to the Owner in writing as part of the submittals. Owner furnished server may be traditional or may be virtual.

2. Backup Power:

   a. Owner-furnished uninterruptible power supply (UPS) with surge suppression.

2.3 CLIENT WORKSTATIONS

A. Provisioning:

1. The workstation(s) shall be furnished by the Owner and shall meet the specifications defined by the SMS software manufacturer to meet or exceed the functionality and performance specifications of the system and integrations defined in this and related sections. Contractor shall furnish specifications to the Owner in writing as part of the submittals.

2.4 FIELD CONTROL HARDWARE

A. Interior Control Panels:

1. Control boards, power distribution and terminals shall be enclosed in a NEMA 1 rated enclosure that is key lockable. Contractor shall not furnish padlock. All enclosures that are part of this project shall be keyed alike. Contractor shall furnish and install a mechanically fastened tamper switch on the interior of the enclosure.

2. Control boards are allowed to be in an enclosure separate from the power supplies/power distribution. Should they be in separate enclosures, the interface wiring shall be in rigid metallic conduit, RMC, with Myers hubs at both ends of the conduit.

3. Intra-enclosure wiring shall be dressed using tie wraps and/or covered plastic wire way. Hook-up wires for identical purposes shall have the same color insulation. For example, if one input pair utilizes green and white insulated conductors, all similar inputs shall use green and white insulated conductors. The same color scheme shall be followed for all access control panels that are part of this project.

4. Cabling from field devices such as readers, door position switches, request-to-exit devices and locking devices shall not be directly terminated to the control boards and power supplies. The field devices shall be terminated to terminals located on the left side, right side or both sides of the enclosure back panel. Intra-enclosure wiring shall be routed from the terminals to the control boards and power distribution. Quantity and functional sequence of the terminals shall be identical portal to portal.

5. All devices inside the enclosure, less cabling and batteries, shall be mechanically fastened to a removable solid or perforated metal back panel with either:

   a. Metal or plastic standoffs
   b. DIN rail

6. Hook and loop fasteners, double sided tape or adhesives are not allowed to attach devices to the back panel. Mounting devices to the interior of the door shall only be allowed when the following two (2) conditions are met:

a. The access control hardware manufacturer offers prefabricated enclosures with devices mounted to the interior of the door.

b. Only the same devices that the access control manufacturer mounts to the interior of the door are allowed to be mounted in a different enclosure, and those devices shall be mounted in an identical manner.

7. 120V 20A input power shall be hard wired to a circuit breaker disconnect and to one duplex receptacle on the interior of the enclosure. Should devices in the enclosures require plug-in transformers/power supplies, the receptacle shall be utilized. One (1) power strip with integrated circuit breaker shall be located in the bottom of the enclosure as needed.

8. Power to the locking devices shall be provided by a power distribution board with no fewer than four (4) outputs. Each lock shall be individually protected. The power distribution board shall:

a. Provide protection with fuses or positive temperature coefficient (PTC) devices.

b. Provide control so that each output is individually selectable as latching or non-latching with fire alarm activation.

c. Provide control so that each output shall have Fail Safe and Fail Secure terminals.

d. Provide a fire alarm input with associated trigger LED.

e. Provide an individual LED per output to indicate when an input has been triggered and the associated output has been activated.

f. Accept a dry, closed contact input to activate the individual lock outputs.

g. Provide a dry, Form C relay that energizes on activation of the fire alarm input. This output may then be used as a fire alarm input to other power distribution boards in the same or a different enclosure, or may provide input to another device such as a multi-pole relay.

9. Power to control boards, readers and auxiliary devices such as request-to-exit motion detectors shall be provided by a power distribution board with no fewer than four (4) outputs. All devices powered by the same voltage at an individual portal shall be protected by the same fuse or PTC unless current requirements dictate otherwise. Individual fuses or PTCs may protect more than one control board.

10. All access control panels, when populated with control boards and power supplies, shall have the following capacities:

a. Control of a minimum of two (2) portals.

b. Spare capacity of a minimum of one (1) access control portal, two (2) auxiliary inputs and two (2) auxiliary outputs greater than the requirements of the project at the time of system specification.

c. Five (5) spare fuses of each type used, to be in their original packaging, to be located in each power supply enclosure.

d. 50% spare current capacity on all power supplies located in unconditioned spaces and 40% spare capacity for those in conditioned spaces. Lower spare capacities are allowable based on prior approval of Contractor-provided power calculations.

11. Locations where enclosures may be mounted are shown on the plans. Final location, with approval of Owner's representative, shall be selected by Contractor based on distribution of controlled portals and devices.

12. At time of Substantial Completion, Contractor shall furnish a schematic diagram of intra-enclosure wiring and a complete bill of materials for the enclosures and the devices located within. This documentation shall include a schedule of fuses and the device(s) that each fuse protects. This documentation shall be placed by Contractor in a Contractor-furnished print pocket located on the inside of the enclosure door.

B. Intelligent System Controllers (ISC):

1. The controller shall communicate with the host via an on board 10/100 Base T Ethernet port.

2. The controllers shall be a distributed architecture with full peer-to-peer networking capability. Master/Slave controller configurations are not acceptable. All controllers in the system shall be capable of operating in a standalone mode if communication is lost with the server or main controller. In no case shall a controller depend on communication with an upstream controller for proper standalone operation.

3. The communications bus shall be supervised for wiring integrity. If a communication failure is detected, the system shall report the loss. All controllers unable to receive communication shall operate as standalone devices including grant/deny decisions, complete with event buffers. All events shall be uploaded to the server upon restoration of communications.

4. The controllers shall utilize flash memory or similar technology, allowing program updates to be downloaded from the server. Program storage shall be in ROM.

5. The controllers shall have the capacity for 5,000 cardholders and 45,000 transactions. All access decisions involving these cardholders shall be made at the lowest controller level without communication to the server.

6. 32-bit microprocessor controlled.

7. Handle all non-host related access control monitoring and decision making.

8. LED indicators for power, fault and communications.

9. Provide for local and global input/output linking:

   a. The SMS shall support a global linkage feature whereby any input/output/event shall be linked to any other input/output/event in the SMS. Input/output linkages shall be able to span across intelligent system controllers.

   b. System administrators shall be able to create global input/output function lists, each consisting of a sequence of actions to be performed, such as changing card reader modes, activating outputs, and opening or closing anti-pass back areas. Each function list may include up to six actions.

10. Reporting of transactions and status information to the server.

11. Interface with standard reader technologies without special interface hardware, additional logic panels or other integrators. Supported technologies shall include:

   a. 13.56 MHz Contactless Smart with or without biometrics or keypad
   b. 13.56 MHz Multi-technology Smart
   c. Wiegand

C. Reader Interface Module (RIM):

1. Reader interface modules are not shown on the plans. Refer to the installation section of this specification for allowable equipment mounting locations. It is the responsibility of the Contractor to determine the number and configuration of reader interface modules required based on the inherent characteristics of each product line and the requirements and restrictions described in this document.

2. RIM shall interface with and accept data from TTL, Wiegand and RS-485 type readers and door hardware.

3. RIM shall provide a minimum of three (3) inputs per portal for portal position, request to exit and auxiliary input.

4. RIM shall provide a minimum of two (2) outputs per portal for locking device and auxiliary output. Each output shall be Form C and shall be rated at 3A at 28VDC.

5. RIM shall communicate to controller by RS-485.

D. Input Control Module (ICM):

1. The input control module shall provide supervised and non-supervised alarm input zones and monitor/report line fault conditions, alarm conditions, power faults and tampers.

2. Input control modules are not shown on the plans. Refer to the installation section of this specification for allowable equipment mounting locations. It is the responsibility of the Contractor to determine the number and configuration of input control modules required, based on the inherent characteristics of each product line and the requirements and restrictions described in this document.

3. UL 294 and 1076 listed.

4. Each input configurable for normally open or normally closed.

5. Each input configurable for timing.

6. Each input configurable for end of line resistance.

7. Status LEDs for communication to the host, heartbeat and input status.

8. Communications line supervision.

9. AES 128 bit encryption.

10. 2-wire RS485 communications.

11. No fewer than eight (8) inputs per board/control module.

12. Assignment of unit addresses and communications speed.

13. Alarm Masking: The ability to mask the alarm input on a time zone basis.

14. Activate Output: The ability for any input to activate any output.

15. Configuration of Debounce Time: The ability to control the amount of time that an input state change must remain consistent in order for it to be considered a real change of state.

16. Elevator control support for number of floors shown on the drawings.

17. Noise rejection filtering to prevent false alarms.

18. Global Linkage: The ability to link outputs with inputs that are attached to any ICM/output control module (OCM).

19. Checkpoint: The ability to configure an input as a designated stop on one or more guard tours.

20. Entry/Exit Delay: The ability to set up entry/exit delays for inputs that are attached to any ICM. This shall include:

    a. Non-Latched Entry: When an input activates, the alarm will not be reported until the entry delay expires. If the input is still active when the entry delay expires, the alarm will be reported. If the input is not active when the entry delay expires, then the alarm will not report.

    b. Latched Entry: When an input activates, the alarm will not be reported until the entry delay expires. If the input is still active when the entry delay expires and the alarm has not been masked, the alarm will be reported. If the input has been masked when the entry delay expires, then the alarm will not report.

    c. Exit Delay: When an input activates, the alarm will not be reported (operates as if masked) until the exit delay expires. If the input is still active when the exit delay expires, the alarm will be reported. If the input is not active when the exit delay expires, the alarm will not be reported.

E. Output Control Module (OCM) and Functionality:

1. Output control modules are not shown on the plans. Refer to the installation section of this specification for allowable equipment mounting locations. It is the responsibility of the Contractor to determine the number and configuration of output control modules required, based on the inherent characteristics of each product line and the requirements and restrictions described in this document.

2. The output control module(s) shall provide Form C relay contacts for load switching, rated at 3A at 28VDC.

3. Each relay shall support “On” “Off” and “Pulse.”

4. Outputs can be pulsed from 0.1 seconds to 24 hours.

5. Status LEDs for communication to the host, heartbeat and relay status.

6. 2-wire RS485 communications.

7. No fewer than eight (8) outputs per board/control module.

8. Communications line supervision.

2.5 APPLICATION SOFTWARE

A. General Performance:

1. The application software, in conjunction with the associated hardware, shall have the following features, functionality and capabilities. The functions that are to be implemented shall be determined in the planning conference between Contractor and Owner referenced in Part 3 of this section.

2. All Users:

a. All users shall be capable of being authenticated against Active Directory using LDAP before being granted system access. Should the Owner not use Active Directory, the system shall provide a built-in login and credential management tool to permit rules-based access rights on a per-user basis.

b. The access rights shall be selectable on a per-user basis. In addition, user groups shall be capable of being assigned whereby each user group has a common set of access rights. Users shall be capable of being assigned to these user groups by the system administrator.

3. Operators:

a. The SMS operator interface shall be standard Windows style graphical interface allowing point and click access to features such as drop-down menus, radio buttons, check boxes, list boxes and other standard Windows components.

b. On-line Context Sensitive Help: The SMS shall provide on-line context sensitive help files to guide system administrators and system operators in the configuration and operation of the SMS. The help menu shall be available from any window in the SMS by pressing one function key or clicking on the "HELP" icon/selection in the toolbar. Help windows shall be context sensitive so operators and system administrators can move from form to form without leaving the help window. The SMS shall come with complete on-line documentation on CD or the ability to offload the documentation to removable media.

c. Operator Groups: A minimum of 32 operator groups, allowing specific system module privileges to be accessed with each module being granted specific views, edit and execute privileges.

d. Operator Levels: System access shall require a valid operator name and password, governing a specific operator's level of access to each menu item.

e. The SMS shall allow a system operator to login over another system operator who is already logged into the same client workstation without the need to reboot the system. This process shall log the first system operator off alarm monitoring and log the new system operator on, changing any permission necessary for that system operator.

4. Logs, Status, Maintenance, Diagnostics:

a. Historical Log: The system shall allow event history to be written to the hard disk in an archive format. At a minimum, the system shall support 500,000 transactions. Warning messages shall be generated at a user defined level of capacity. The system shall have the ability to offload the archive files to removable media automatically or manually.

b. System Status: The system shall query the status of any or all of the system's access control points, inputs and outputs.

c. System Maintenance/Diagnostics: The system shall provide for remote diagnostic capabilities. In addition, online diagnostics and communications maintenance shall be able to be activated from the operator interface.

5. Administrator:

a. The SMS shall provide system administrators with the ability to segment their access control SMS field hardware devices into various zones or areas where alarm monitoring client workstations will monitor. These zones shall be assigned an alphanumeric name using up to a minimum of 64 characters.

b. The SMS shall allow other devices such as card readers, input and output modules and intelligent system controllers to be automatically part of the monitoring zone when an intelligent system controller is selected, and it shall allow the system administrator to define which devices such as card readers, etc. belong to that monitor zone.

c. Updating of monitor zones shall take place in real time and without requiring operators to re-login.

6. General:

a. Elevator control support for the number of floors and cabs shown on the drawings.

b. The SMS software shall be written to Microsoft's published standards for user interface design, secure coding practices and database implementation guidelines such as Microsoft Open Database Connectivity (ODBC) interface.

c. All tasks shall be accessible from any compatible client workstation on the network using one or all of the following:

1) Traditional client/server architecture.

2) N-Tier architecture where the SMS shall support the expansion of the system architecture and allow for end-user deployment. The SMS shall allow, but not require, the separation of the database, application server, web server and client interface. The system shall require that all connections to the database be performed through a trusted link from the client or internet browser interface.

3) Centralized publishing of applications using Windows Terminal Server and Citrix through any compatible internet browser application and/or by mobile computer including tablet PC.

d. The SMS shall use an open architecture where all data must reside on a single database and must be accessible in real time to every SMS workstation or web-based client connected to the network. The system database shall be used to create and maintain the cardholder database. A screen designer module shall allow the creation and editing of custom database tables and data entry screens.

e. The SMS shall be able to connect to and interface bi-directionally with external data sources using all of the following methods:

1) ASCII with support for XML-formatted text exchange of data activated both manually and automatically.

2) ASCII with support for XML-formatted text exchange of data using a direct table interface activated both manually and automatically.

3) Real time exchange of data via Active Directory/LDAP utilizing an API supported by the SMS manufacturer. The live exchange of data shall permit exposure of SMS events and transactions to other data sources in real time and allow for receipt of data into the SMS, permitting this data to be acted upon and trigger linked events in the SMS in real time.

f. Security: Access privileges within the application software shall be permitted by use of a password protection system. The cardholder database shall have the following password security levels.

1) A minimum of six (6) unique operator access levels
2) Ability to view only the database fields
3) Ability to restrict operator viewing to any of the individual database screens within a record
4) Ability to restrict operator viewing to any of the database partitions

g. Cardholder Configurations: The system shall have the capacity to support a minimum of 5,000 cardholder files. Each cardholder shall be capable of having up to five (5) access levels actively assigned to their account.

h. The cardholder database screen shall have the following data associated with each cardholder:

1) Last edit by operator with edited date and time
2) Last date/time card was used
3) Last reader giving valid access
4) Last reader denying access
5) Anti-pass back status

i. The system shall provide advanced query capability with the following search criteria: equal to, not equal to, greater than, greater than or equal to, less than, less than or equal to, like, is empty, is not empty, is between, and, or, not.

j. Access Control Configuration: The configuration application shall be password protected, restricting what each individual may edit or display inside the configuration application.

k. Text descriptions of access points such as doors.

7. Time Zones:

a. The SMS shall be capable of creating and storing up to 255 time zones. Each time zone shall have a minimum of six (6) intervals. Each interval shall be assignable to any day of the week.

b. Each time zone shall be assignable to an alphanumeric name. Time zones shall be applied to access levels, card reader modes, alarm inputs, alarm outputs, and alarm masking and logging functions. Time zones shall be allowed to belong to any or all access levels so that the time zone only has to be defined once.

8. Access Levels:

a. The SMS shall be capable of defining a minimum of 32,000 access levels with a minimum of 32 access levels per cardholder per database segment. Access levels shall consist of a combination of card readers and time zones.

b. Each access level shall be assignable to an alphanumeric name.

c. Card readers shall have the ability to be assigned to any or all access levels defined in the SMS. Individual card readers shall be capable of having a distinct time zone assigned to it.

d. The SMS shall allow an 'Allow User Commands' option to be assigned on a per access level basis where keypad readers are in use.

e. The SMS shall allow a 'First Card Unlock' option to be assigned on a per access level basis. First Card Unlock feature, when configured, retards a pre-determined time zone activated unlock command until a valid credential has been presented and granted access to the portal.

9. Temporary Access Levels:

a. The SMS shall be capable of assigning temporary access levels inclusive of the 32,000 assignable access levels.

b. Each temporary access level shall be assignable to an alphanumeric name.

c. Each temporary access level shall be definable with a start and end date.

d. Temporary access levels shall be stored in the ISC, and functionality shall be maintained in the event of disconnection with the ISC.

10. Access Groups:

a. The SMS shall be capable of assigning access groups, with a maximum of 32 access levels per access group.

b. Each access group shall be assignable to an alphanumeric name.

11. Precision Access Levels:

a. The SMS shall be capable of assigning precision access levels in addition to the 32,000 access levels, with the ability to assign unlimited card reader and time zone combinations. Precision access levels provide capability of assigning a unique access level on a per card basis.

b. Each precision access level shall be assignable to an alphanumeric name.

12. Holidays:

a. The SMS shall provide a minimum of 255 holiday assignments using an embedded calendar. Holidays shall be assigned an alphanumeric name and shall be grouped into eight (8) types of holidays, and shall be assignable to individual time zones. Access rights, card reader modes, and alarm masking schedules must be able to be altered when the current date is designated as a holiday.

b. Dates for Daylight Saving Time changes shall be definable and shall take effect automatically.

c. The SMS shall support holiday ranges that allow a single holiday to span across multiple calendar days.

13. Database Segmentation:

a. The SMS shall be required to support data segmentation whereby each segment shall have its own set of cardholders, field hardware, and system parameters (time zones, access levels, etc.). This segmentation shall expand the limitations of the SMS parameters (e.g., access levels and time zones) to the maximum capacity of each parameter multiplied by the number of segments. The following list shall be made available for segmentation:

1) Access group
2) Access levels
3) Actions
4) Action groups
5) Alarm inputs
6) Alarm mask groups
7) Alarm outputs
8) Areas
9) Credential types
10) Card formats
11) Cardholders
12) Card readers
13) Central station receivers
14) Device groups
15) Digital video archive servers
16) Fire alarm panels
17) Guard tours
18) Global I/O function lists
19) Global I/O links
20) Holidays
21) Intercom panels
22) Intercom stations
23) Intrusion detection panels
24) ISCs
25) Maps
26) Monitor zones
27) Precision access groups
28) Receiver accounts
29) System operators
30) Time zones
31) Tour groups
32) Visitors
33) User permission groups

14. Field Hardware Communications:

a. The SMS shall support communications with the intelligent system controllers (ISCs) by the following protocols:

1) TCP/IP

b. Download communication between the SMS and the ISC shall be fully multi-tasking and shall not interfere with operational functions.

c. Upon loss of communications between the SMS server and the ISC, an alarm shall be created with a time stamp. Upon re-established communication, the SMS and the ISC shall automatically re-synchronize from the point of communication loss without operator intervention.

15. Intelligent System Controller Remote Support:

a. The SMS shall support remote operations to and from the intelligent system controller (ISC). The remote connection shall be either a constant connection or a scheduled connection. If the connection is constant, then every panel shall have its own connection at the host. If the connection is scheduled, then all panels using remote connections shall have the ability to share the same host connection(s).

b. System administrators shall have the ability to define the remote connections available in the pool. For each connection, system administrators shall be able to define the connection type and the client workstation to which it is installed.

c. Remote sessions shall occur under any of the user defined scenarios:

1) On Demand Connection: A system operator shall have the ability to automatically initiate a remote session to an ISC via the alarm monitoring module.

2) Scheduled Connection: System administrators shall have the ability to configure the SMS so that the ISC remotes into the SMS at pre-determined times through use of time zones.

3) Critical Alarm Activated: System administrators shall have the ability to configure the SMS so that the ISC initiates a remote session with the SMS when a critical alarm is activated in the field.

4) Buffer Threshold: System administrators shall have the ability to configure the SMS so that the ISC initiates a remote session with the SMS when a pre-determined number of events are stored in the ISC memory buffer.

d. Extended Individual Door Held Open Times:

1) The SMS shall support Extended Individual Door Held Open Times that allow a card reader’s door to be held open for an extended period of time beyond the pre-determined standard held open time on a per cardholder basis. The extended held open time shall be user definable up to eight (8) hours. Extended held open times shall be set on a card reader by card reader basis.

e. Extended, On Demand, Door Held Open Times:

1) The SMS shall support Extended, On Demand, Door Held Times via a command keypad located in the field. The Extended Held Open command configuration shall consist of a command key sequence that shall be from three to six keys used to enter the number of minutes to extend the door held open time (up to 999 minutes) and a pre-alarm time (from 0 to 30 minutes).

2) Only those cardholders having command authority at a given card reader configured for ‘Allow User Commands’ shall have the ability to execute the Extended Held Open command at that card reader. The Extended Held Open command shall be available after a valid cardholder has received an access grant at the card reader. The cardholder shall have a period of 15 seconds after the access grant to enter the extended held open command sequence.

f. Graphical System Overview Tree:

1) A Graphical System Overview Tree shall display a graphical representation of all field hardware including hardware from other systems which are interfaced, System administrators shall be able to modify a device that is depicted on the Graphical System Overview Tree or see its properties by double clicking on the icon, and the SMS shall bring them to the appropriate form.

g. Pre-Alarm:

1) The SMS shall support a Pre-Alarm feature at the card reader. The pre-alarm will sound a tone at the card reader prior to the door held open alarm. The pre-alarm setting shall be configurable for up the maximum allowable door hold open time.

h. Alarm/Event Logging:

1) All alarms and events in the SMS shall, by default, always be recorded in the database. The SMS shall give system administrators the ability to select, on a time-zone basis, the times that they require the SMS to log specific events to the database.

2) System administrators shall have the option for particular alarm/events to be set to log or not to log on any individual reader and/or input.

i. Scheduling Utility:

1) The SMS shall provide an integral Scheduling Utility. The Scheduling Utility shall allow system administrators to schedule actions to occur on a one-time or a recurring basis. Recurring schedules shall be configured to begin immediately, last indefinitely, or have optional start and end dates.

2) The Scheduling Utility shall be available from both the system administration and alarm monitoring modules.

3) The types of actions that shall be schedulable include, but are not limited to:

a) Action Group
b) Event Archiving/Purging
c) Arm/Disarm Area
d) Start of Guard Tour
e) Execution of Scripts
f) Activate, Deactivate, Pulse Device Output and Device Output Groups
g) Global Anti-Pass back Reset
h) Download Firmware to equipment.
i) Download Database to ISCs
j) Execute Function List
k) Mask/Unmask Inputs, Input Groups, Alarm Mask Groups, Door Forced Open or Held Open
l) Open Door, Open Door Group
m) Change Reader Mode
n) Automatic Reports
o) Reset Use Limit
p) Move Bulk Credentials from an Area
q) Deactivate Credentials
r) Logout Visitors
s) Schedule PTZ Presets

4) The Scheduling Utility shall maintain a history log in the database for actions that it executes.

16. Multiple Card Formats:

a. Each ISC shall support a minimum of eight (8) access control card formats and, if applicable, eight (8) asset formats.

17. Denied Access Attempts Counter:

a. The SMS shall support a Denied Access Attempts Count on a per card reader basis. The “Denied Attempts Count” value shall be configurable from 0 to 255. The following access denial types shall cause the current denied count to be incremented:

1) Unknown PIN entry at a card reader configured as ‘PIN or Card’ mode.

2) Invalid cipher entry at a card reader in Cipher Mode.

3) Invalid PIN entered for a given card at a card reader configured as ‘Card and PIN’ mode.

4) Non-matching biometric presented for a given card at a card reader in Biometric Verify mode.

18. Card Reader Time Zone Overrides:

a. The SMS shall allow for the pre-defined default card reader settings to be overridden or temporarily changed on a time-zone basis. At the beginning of the selected time zone, the selected card reader's operational mode shall be modified from its default mode to any one of the following modes: Locked, Unlocked, Facility Code, Card Only, Card or PIN, Card and PIN, Card and Biometric, Card or PIN and Biometric, and/or Card and PIN and Biometric. The aforementioned options shall be available depending on the type of card reader used.

b. Each card reader shall have the ability to have multiple time zone setting overrides assigned to them as required by the system administrator.

19. Alarm/Event Routing:

a. The SMS shall be capable of allowing system administrators to route alarms and events to various alarm monitoring client workstations on the network. The SMS shall allow any alarm or event to be routed to one or multiple client workstations on the network regardless of where the alarm is generated in the field. Alarms shall be routed to client workstations on a device-by-device level.

b. The SMS shall be capable of automatic re-routing of an alarm from workstation X to workstation Y if the alarm is not responded to within a user definable time period.

c. The SMS shall implement network synchronization such that in the event that an alarm is routed to multiple client workstations, once the first client workstation acknowledges the alarm, the alarm shall be cleared from all other client workstations. As such, alarms that are routed to an Alarm Monitoring client workstation that does not have a System Operator logged in shall be queued so that all unacknowledged alarms will report to that client workstation once a System Operator has logged into the SMS. Alarms/Events shall be routed based on default settings or time zone control.

20. Alarm Attributes:

a. The system administrator shall have the ability to configure how the SMS handles the annunciation of alarms on an individual basis. Each alarm and/or event shall have the option(s) to:

1) Display at one or more alarm monitoring client workstation.

2) Allow higher priority alarms to be displayed on the alarm monitoring client workstation ahead of lower priority alarms.

3) Require the field device that generated the alarm to be restored to its normal state before the alarm is cleared.

4) Print the alarm to the local event printer.

5) Have a customized voice message annunciate at the client workstation.

6) Have the alarm breakthrough to the alarm monitoring window should the system operator be working in another application

7) Allow system operators to change the journal entry once the alarm has been acknowledged.

8) Ensure that the alarm will not be able to be deleted from the alarm monitoring window upon acknowledgment.

9) Display text and audio instructions outlining the procedures to follow when responding to the alarm.

10) Automatically call-up associated maps.

11) Automatically call up the associated cardholder record.

12) Automatically call up the associated cardholder photo using the video verification function.

13) Require a password to view the alarm.

14) Require a password to acknowledge the alarm.

15) Require acknowledgment to clear.

16) Allow mandatory journal entry upon acknowledgment.

17) Use pre-defined journal entries for alarms.

18) Select the option for journal entry based upon the specific alarm.

19) Send surveillance interface commands to the surveillance system.

20) Automatically send an e-mail message.

21) Automatically send an alphanumeric page.

22) Have the alarm appear on the alarm monitoring window with a flashing colored coded bar across the alarm for high priority alarms.

23) Have the alarm, when acknowledged, display an alternative flashing color coded bar across the alarm than for the original alarm color.

24) Trigger a function list(s) when the alarm is acknowledged.

25) Require user logon for acknowledgment.

26) Have the ability to mark an alarm as “In Progress” where the system shall silence any repeating audio notifications on the workstation where the alarm was routed, and remove the alarm sprite notification on the graphical map. Additional operators’ monitoring alarms shall be notified that the alarm has been marked “In Progress”.

21. Alarm-Event Mappings:

a. The SMS attributes in Alarm Attributes shall be assignable on a ‘global’ basis to all devices that share an alarm description. Thus, the ‘Door Forced Open’ alarm attributes shall apply to any door with a card reader that is forced open in the SMS. The SMS shall have the capability to assign a unique group of alarm attributes to specific device/alarm combinations to override the global settings for specific case settings. Each device/alarm combination shall have the ability to have its own unique attribute set if the system administrator desires.

22. System Downloads:

a. The SMS shall provide for the downloading of data to the ISCs. Downloads shall load SMS information such as time zones, access levels, alarm configurations, cardholder information and card reader configurations.

b. All ISCs on the SMS shall be capable of either full or selective downloads to individual intelligent system controllers, and bi-directionally so that alarms will still report to their respective alarm monitoring client workstations as cardholder information is being downloaded.

c. Information on cardholder status, credential status, time zones or access levels shall download in real time as they are added, modified, or deleted from the SMS.

23. Portal Configuration Options:

a. The SMS shall include the following options for each portal on the system:

1) Allow user commands such as manual door unlock
2) Rename auxiliary inputs
3) Rename auxiliary outputs
4) Independently supervise REX and DPS
5) Configure REX and DPS as Normally Open or Normally Closed
6) Deny if duress
7) Assume door used
8) Alarm masking
9) Activate outputs
10) Two card control
11) Checkpoint
12) Do not activate strike on REX
13) The ability to allow system administrators to determine on a time-zone basis to log or not to log on a card reader by card reader basis
14) Access grants

15) Access denied
16) Card reader status alarms
17) The SMS shall allow for user definable door strike functionality for each card reader in the SMS
18) The SMS shall allow for each card reader to be selected as either an 'In' reader, 'Out' reader, or 'None' to allow for ease of reporting time and attendance basic 'Time In' and 'Time Out' data.
19) Enforce Use Limit: This option shall enable card use limits at the card reader. limiting the number of times that cardholders may use their credential to gain access at the card reader
20) Supervise Door: Sets the SMS so that the card reader door contact is wired as a supervised input

24. The SMS shall allow for one or more access points in a specified area to be armed and disarmed directly from a control keypad.

25. Real-Time, Live Video User Verification:

a. The SMS shall have the capability of interfacing to a surveillance system and displaying a live video image next to a stored cardholder image record. This feature shall be system configurable.

26. Traces:

a. The SMS shall allow for a live or historical trace on any ISC, ICM, alarm input, credential (cardholder), intrusion detection device, monitor zone, or card reader. If applicable, the SMS shall allow for a trace on any asset, intercom, or camera. Multiple traces may be run simultaneously. The SMS shall allow system operators to filter alarm types from the history trace window. Alarms that shall be filtered from the trace window are access granted alarms, access denied alarms, system alarms, duress alarms, and area control alarms.

b. Destination Assurance: The system shall provide the ability to alert the system operator when a cardholder does not reach a required location and present their credential after entering at a designated checkpoint in a designated period of time.

2.6 ACCESS CONTROL GRAPHICAL USER INTERFACE (GUI)

A. A workstation based custom GUI shall be provided for complete display of real time system activity.

B. The GUI shall provide the following features:

1. Display in real-time, the status of devices by dynamically changing shape or color to indicate status.

2. Acknowledge alarm conditions.

3. Perform manual operations on all monitor and control points.

4. Perform graphic editing functions.

5. Customization of icons color or shape based on status.

C. Graphical representations shall be made of the following activity:

1. Cardholder Activity: Access granted (including duress), access denied, lost card used, stolen card used, inactive card used, unescorted visitor.

2. Input Point Activity: Input condition (normal, abnormal, cut, short, shunt, unshunt).

3. Output Point Activity: On status (automatic, by operator, by link), off status (automatic, by operator, by link), access level on, access level off.

4. Door Activity: Auto unlock, auto lock, closed, opened, forced open, left open, door switch cut, door switch shorted, REX status (cut, shorted, normal, abnormal), input unlock, operator lock, operator unlock.

5. Controller Activity: Controller on-line, controller off-line, controller communications normal, communications cut.

6. System Activity: System error, workstation start, workstation stop, printer off-line, printer unavailable, printer overflow, unknown card.

7. Regional Group Activity: Occupancy restriction (high limit, low limit), anti-pass back (entry, exit), policy violation, escort left, number of escorts, numbers of users, number of visitors.

D. The GUI shall have the ability to display a minimum of 100 custom graphical screens, developed by the SMS vendor with electronic maps provided by Owner.

E. The system shall have the ability to automatically call up specific maps. Each input point shall be linked to a primary map.

F. Graphical editing software shall be included, allowing the Owner to create and edit the graphical screens.

G. Graphics screens shall be developed using a minimum of eight (8) colors from a palette of 64 available.

H. The system shall operate on a Windows workstation as provided and recommended by the SMS vendor.

2.7 CREDENTIALS AND BADGING

A. Badging Station:

1. Provisioning:

a. The workstation(s) shall be furnished by the Contractor and shall meet the specifications defined by the SMS software manufacturer to meet or exceed the functionality and performance specifications of the system and integrations defined in this and related sections. Contractor shall coordinate with Owner for possible requirements to utilize a specific manufacturer. Contractor-furnished workstation(s) shall have a three (3) year limited warranty.

2. Software:

a. General:

1) The SMS shall support a credential design module that is integral to the SMS source code with the ability to create and maintain credential designs. Features shall include the ability to support:

a) Complete credential design and layout tools
b) Chroma key
c) Image import
d) Ghosting
e) Signature capture
f) Barcodes
g) Smart chip support

b. Licensing

1) Required badging/credential management licensing shall be furnished.

3. Hardware:

a. Workstation by owner
b. Printer:

1) Printer Manufacturer shall be:

a) Fargo
b) Magicard

2) The SMS shall support a printer with industry standard and Microsoft certified drivers. The printer shall support:

a) Double sided printing at a resolution of no less than 300 dpi, full color on the front, monochrome on the back
b) Edge to edge printing
c) High speed printing per card of a minimum of 7 seconds for monochrome and 35 seconds for YMCKO
d) Holographic overlay
e) Inline magnetic stripe encoding
f) Inline Contactless Smart card encoding
g) An input feeder/hopper with a minimum capacity of 100 cards and an output stacker/hopper with a minimum capacity of 30 cards

c. Images:

1) Camera:

a) The badging station shall be compatible with flash lighting and USB connected cameras, allowing the capture of a cardholder image at a minimum resolution of 3 mega pixels.

b) SMS image capture, storage, and hardware compression techniques must be in compliance with the ANSI standard or JPEG (Joint Photographic Experts Group).

c) The SMS shall provide the ability to capture a cardholder's image through the use of any industry standard scanner or digital camera that utilizes a TWAIN interface. Images shall be able to be scanned at up to 16.7 million colors for a true color scanned image. When using a digital camera that supports multiple resolutions, the system shall allow the operator to select the desired resolution.

2) Image Import:

a) The SMS shall allow system operators to have the ability to import a cardholder's image at the time of enrollment. The SMS shall support importing image formats of Bitmap (.bmp, .dib), JPEG (.jpg), JFIF (.jif), Adobe Photoshop (.psd), Macintosh PICT (.pct), Portable Network Graphics (.png), TIFF (.tif), Windows Metafile (.wmf, .emf).

4. Badge Design:

a. Provide training and work in conjunction with Owner for development of four (4) badge designs.

b. Cleaning Kits:

1) One cleaning kit shall be provided for every ribbon provided.

c. Lanyards and Sleeves:

1) Lanyards and badge sleeves shall be furnished by Owner.

d. Badge Quantities:

1) Badge quantities and types shall be as defined below.

B. Credentials:

1. Multi-Technology Contactless Smart Cards: 13.56 MHz and 125 kHz proximity radio frequency identification electronics, passive design. Card shall meet ISO 15693 and ISO 14443B2 standards.

a. Maximum Dimensions: CR 79: 3.313" x 2.063" x 0.04", CR 80: 3.375" x 2.125" x 0.04".

b. Construction to be of PVC or polyester laminate.

c. Each card shall contain a unique serial number.

d. Cards shall contain options for various memory capacities of 2k, 16k or 32k with a fixed number of application areas or areas which are sized by dynamic allocation.

e. Each application area shall contain a unique authentication key. The card and reader shall require matching keys in order to function together. All RF communication between card and reader shall be encrypted using a secure algorithm.

f. Cards shall be encoded with bit lengths that are compatible with all other components of the SMS.

g. Cards shall support programming and updating of custom applications after issue.

h. Cards shall be capable of having a photo and/or other graphical images printed directly on the surface of the card.

i. Provide optional slot punch-outs on the short and long edge of the card.

j. Provide min. 10 multi-technology cards. Cards shall be individually numbered with sequential matching of internal and external numbers.

k. Cards shall be provided with a lifetime warranty;

C. Credential Management:

1. The SMS shall support a Credential Management and Enrollment module that is integral to the SMS source code with the ability to create and maintain the cardholder database. Features shall include the ability to:

a. Add, modify and delete records based upon permissions
b. Capture photo images, biometric information and signatures
c. Print credentials
d. Boolean search on any single or multiple fields
e. Customization of screen layout and field names
f. Advanced customization of fields, field names and screen tabs (pages) with optional Forms Designing and Editing module
g. Determine single or multiple active credentials
h. Assign access levels and access groups
i. Bulk assignment/modification/deletion of access levels
j. Bulk deletion of cardholder records.
k. Native support for U.S. Government CHUID Standard
l. Limit the number of times the credential can be printed
m. Limit the access for searching the database based upon user defined criteria
n. Mobile badging operations.

2. The SMS shall support the following bar codes:

a. Code 3 of 9 (3:1)
b. Code 93
c. UPCA
d. EAN 13

e. EAN 8
f. Code 128 A
g. Code 128 B
h. Code 128 C
i. Codabar
j. PostNEt (Zip + 4 Postal)
k. Code 3 of 9 (2:1)
l. Interleaved 2 of 5 (2:1)
m. PDF-417 (2D)
n. Code 128 Auto
o. UCC-128
p. MSI Plessey
q. Extended Code 3 of 9
r. Extended Code 93
s. 2D Aztec

2.8 PORTAL DEVICES

A. Credential Readers:

1. Manufacturers:

   a. HID Multiclass SE

2. Multi-Technology:

   a. Compatible with 125 kHz proximity, 13.56 MHz Contactless Smart card, MIFARE, DESFire EV1.

   b. Backwards compatibility with legacy 13.56 MHz Contactless Smart cards and 125 kHz proximity access control formats, including 26, 32, 35, 37 bit as well as HID Corporate 1000 format.

3. Card readers manufactured specifically for non-access control applications shall not be acceptable.

4. Provide compatibility with most access control systems by providing card data outputs in Wiegand and Clock/Data.

5. Allow the firmware to be updated in the field without the need to remove the reader from the wall.

6. Secure mounting methods using tamper resistant screws.

7. An audio beeper that provides various tones to signify access granted, access denied, power up and diagnostics.

8. Tri-color LED or three (3) LEDs for visual notification of various conditions.

9. ISO1443A, 1443B and 15693 compliant.

10. The ability to transmit an alarm from an integrated tamper switch.

11. Support dual authentication of identity through the combined use of access badge and personal identification number (PIN) on an integrated 12 key keypad.

12. PBT polymer or UL94 polycarbonate.

13. Read Range:

    a. Using 125 kHz cards or 13.56 MHz Contactless Smart cards, minimum operational read range shall not be less than one (1) inch after the readers have been installed in their permanent locations.

14. Operational voltage of 5-16 VDC, with operating temperature range of -31° F to 150° F, and rated for outdoor use with a minimum rating of IP55.

15. Readers and credentials shall be compatible with each other and shall be from the same manufacturer.

16. Available in sizes to be mounted to a standard single gang box or to a mullion. Maximum sizes:

    a. Single gang box mount, with or without keypad: 5.1" x 3.1" x 1.1"
    b. Mullion mount: 6.0" x 1.9" x 0.9"

17. Lifetime warranty against defects in material and workmanship.

B. Gate Position Switch

1. Manufacturers:

    a. GE
    b. GRI
    c. Honeywell
    d. Pre-approved equal

2. Gate:

    a. Maximum 1.5 (1-1/2) inch gap
    b. DPDT contacts
    c. Three feet (3') stainless steel armored cable
    d. Aluminum construction
    e. Basis of Design: UTC/GE/Sentrol 2507AD

C. Cable:

1. Composite cable is allowed, although sufficient conductors may not be available in composite cables for all portal configurations. Contractor shall be responsible for additional required cables beyond one composite cable to each portal to meet functional requirements of the system.

    a. Reader: 16 AWG, 3 pair, stranded, overall shield. Shield shall be grounded at control panel end only.Request to Exit Motion Detector: 22 AWG, 4 conductor, stranded.

    b. Door Position Switch: 16 AWG, 2 conductor, stranded.

c. Lock: Minimum 16 AWG, 4 conductor, stranded.

1) Lock may require heavier gauge cable depending on door hardware solution power requirements. Contractor shall coordinate with door hardware provider for higher current devices and shall adjust the gauge of the lock cable accordingly.

d. Auxiliary Devices: Refer to plans for requirements.

D. Locks and Door Hardware:

1. Electric/electronic locks shall be furnished and installed by the door hardware provider.

2. Access Control Contractor shall interface with and terminate cables to locks.

3. Access Control Contractor shall coordinate with door hardware provider for specified sequences of operation at the various portals.

4. Refer to architectural specifications and/or the architectural door schedule.

2.9 ASSET MANAGEMENT

A. The Asset Management System (AMS) shall be provided as an integrated solution that is seamlessly integrated with the SMS and all integrated SMS systems. All asset data shall be stored in the SMS database, and all related functions and features of the SMS shall be incorporated into the AMS.

B. The AMS shall employ a distributed architecture so that all access / asset decisions are only made locally at the ISC. All assets shall be stored locally at the ISC, and all decisions to grant asset access shall be made by the local ISC. Decisions made at the Host or Database Server PC shall not be allowed.

C. The AMS shall employ asset technology independence. The AMS shall support multiple asset technologies including radio frequency identification (RFID) and barcode.

D. The AMS shall support multiple card reader technologies. The AMS shall support any card reader that outputs a standard Wiegand communications protocol, including proximity and barcode readers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with the manufacturer’s instructions and recommendations for installation of all products.

B. Provide all system wiring between all components as shown on the project drawings or as directed by the manufacturer, whichever is the more stringent requirement.

C. Network controllers shall be installed centralized in the nearest telecommunications room(s). Mount controllers to the structural walls in a location coordinated with other utilities.

D. Provide wiring and connection to all electrified locking hardware devices. Complete programming and testing of all electrified locking hardware devices.

E. Install all credential readers in accordance with manufacturer’s instructions where shown on floor plans, in accordance with the Americans with Disabilities Act (ADA) requirements. Provide wiring and connection to all credential readers. Complete programming, adjustment, and testing of all credential readers.

F. Provide wiring and connection to all hardware request-to-exit devices that are integral to electrified door hardware. Provide wiring and connection to all request-to-exit motion detectors. Complete programming and testing of all integrated request-to-exit devices. Where possible, avoid false activation by persons passing by but not exiting.

G. Install all request-to-exit motion detectors in accordance with manufacturer’s instructions directly above the door frame, centered on the door opening. Adjust sensitivity to permit operation on motion of persons within 2'-0" of door. Avoid false activation by persons passing by where possible.

H. Install all request-to-exit pushbuttons in accordance with manufacturer’s instructions where shown on floor plans, in accordance with the Americans with Disabilities Act (ADA) requirements. Provide wiring and connection to all request-to-exit pushbuttons. Complete programming, adjustment and testing of all request-to-exit pushbuttons.

I. Install all door alarm contacts in accordance with manufacturer’s instructions either recessed in the door header or surface mounted as required. Provide wiring and connection to door alarm contact devices. Complete programming, adjustment and testing of all door alarm contacts.

J. Install all duress switches in accordance with manufacturer’s instructions, surface mounted under counter in locations shown on plans. Verify exact mounting location with Owner prior to cable rough-in or installation. For hard wired devices, provide wiring and connection to duress switch devices. For wireless duress switch devices, mount receivers in accessible locations. Complete programming, adjustment and testing of all duress switch devices. Wireless testing shall include signal reception when transmitter is in all sections of the area in which it will be used in normal operations.

K. Install, wire, configure, adjust, program and test all access control system servers, workstations, badging workstations and other user interfaces.

L. Install, wire, configure, adjust, program, and test all specified interfaces and integrations between access control and other systems. Contractor shall provide all cabling, wiring, terminations, components, devices, accessories, hardware, software and other material and accessories necessary to complete all specified interfaces and integrations and make them fully operational.

M. All low voltage access control cabling shall be installed in conduit from end to end. Electronic access control system cabling shall not be spliced.

N. Flexible conduit is not allowed except with prior approval. Refer to Section 26 05 33 for conduit requirements. Refer to Section 27 05 28 for cable hanger and support requirements.

O. Each cable shall be appropriately identified, as defined on the record documents, at each end’s termination point using pressure sensitive label strips.

P. The conductor color code used in terminating system cabling at system devices shall remain consistent from device to device for each unique device type throughout the project.

Q. Install and tighten all connectors in accordance with manufacturer's instructions using the appropriately designed tools recommended by the manufacturer for that purpose. Do not strip or damage connectors, terminals, or equipment by over tightening termination fasteners.

R. Grounding and Bonding Requirements:

1. Provide a minimum of 6AWG bonding conductor from each electronic access control system control panel, power supply and surge suppression device to the nearest telecommunications grounding busbar. Actual bonding conductor size is determined by its length; refer to Section 27 05 26 for grounding and bonding conductor sizing criteria.

2. Cables containing shields shall not have the shields grounded at conduits, boxes, racks, etc. Ground the shield only at the control panel end.

S. Coordinate installation of all devices with other trades and utilities in the vicinity.

T. Cabling shall be plenum rated when installed outside conduit in plenum ceilings.

3.2 FIELD QUALITY CONTROL

A. Where these specifications require a product or assembly without the use of a brand or trade name, provide a product that meets the requirements of the specifications as supplied and warranted by the system vendor. If the product or assembly is not available from the system vendor, provide product or assembly as recommended by the system vendor.

B. Periodic observations will be performed during construction to verify compliance with the requirements of the specifications. These services do not relieve the Contractor of responsibility for compliance with the contract documents.

C. Furnish products listed and classified by Underwriters Laboratories, Inc. (UL) as suitable for purpose specified and indicated.

3.3 MANUFACTURER AND INTEGRATOR COMBINED FIELD SERVICES

A. Installation shall be performed by a factory-trained and certified Contractor.

B. The Contractor shall provide a comprehensive, site-specific customer planning guide for the system. The Contractor shall conduct conference(s) with the Owner prior to any installation to discuss the programming and configuration options of the system and the planning guide.

C. The Contractor shall include labor for all planning and all programming activities required to implement the Owner's access policies for each system point and each operator and administrator. Any software programmable access policy, within the bounds of the hardware specified, shall be included.

D. It shall be the responsibility of the Contractor to provide a complete, functional system as described by the design documents. These responsibilities include:

1. Complete hardware setup, installation, wiring and software configuration of the system server, all workstations and all peripheral hardware.

2. Complete programming of all operator software in accordance with the Owner's access policies determined by the planning guide conference(s).

3. Manual data entry of 10 cardholders based on a printed roster provided by the Owner.

4. Configuration of the network software for operation of the system. Templates shall be established representative of all user access right levels.

5. Programming of all cardholder database screens including cardholder information screens, report templates, queries, etc. Encoding of 10 proximity cards shall be included.

6. Programming of all custom graphic GUI screens including devices.

7. Complete system diagnostic verification.

E. The SMS Installation Contractor shall be present at meetings to coordinate all door hardware requirements with the door hardware vendor.

3.4 SYSTEM DOCUMENTATION

A. Complete documentation shall be provided for the system. The documentation shall describe:

1. All operational parameters of the system
2. Complete documentation of programming and access policies
3. Complete operating instructions for all hardware and software

B. The following sections shall be provided in the system documentation:

1. System Administrator Manual: Provides an overview and a step-by-step guide and instructions detailing all system administrator responsibilities and functions.

2. User Manual: A step-by-step guide and instructions detailing all system user functions.

3. Alarm Monitoring Manual: A step-by-step guide and instructions detailing all alarm monitoring system functions and responsibilities.

4. Technical Maintenance Manual: A comprehensive document providing all maintenance actions, system testing schedules, troubleshooting flowcharts, functional system layout, wiring diagrams, block diagrams and schematic diagrams.

5. Refer to Part 1 for details.

3.5 SYSTEM TRAINING

A. All labor and materials required for on-site system training by a certified representative of the system manufacturer shall be provided. Training shall be conducted at the project site using the project equipment.

B. Coordinate training days and times with Owner.

C. Provide a training outline agenda describing the subject matter and the recommended audience for each topic.

D. At a minimum, the following training shall be conducted:

1. System Administrators: A course detailing the system functions, configurations and operations. Provide training on all aspects of the system including data import/export, report, cardholder management, system workstation and server configuration and maintenance, software and hardware configuration and peripheral hardware operation.

2. Operators: A course detailing the operational features of all aspects of the user interface. Topics shall include alarm monitoring functions, reports, error handling, alarm handling, output relay control, operation of integrated systems interface, and general overview of the report hardware.

3. GUI Editing: Conduct detailed training on using the GUI editing software. Topics shall include the editing of existing graphical maps and the creation of new graphical maps.

E. Minimum on-site training times shall be:

1. System Administrators: Four (4) hours

2. Operators: Eight (8) hours.

3. GUI Editing: Eight (8) hours.

4. Integrations : Eight (8) hours

5. Badging System: Four (4) hours.

6. Four (4) additional hours of training each quarter for the 12-month period of the project warranty shall be provided. A minimum of half of this additional training shall be on site; the remainder may be support by telephone or email. Contractor shall document this training, including dates performed, trainer and Owner representative(s) present. Each phone call or email shall be documented as a minimum of 15 minutes duration.

3.6 SYSTEM ACCEPTANCE

A. The SMS vendor shall submit for review a formal acceptance and system checkout program. The system checkout procedures shall include all system components, software and functionality. The Contractor shall perform the tests and document all results under the supervision of the manufacturer’s systems engineer.

B. All operational scenarios, as defined by the customer planning guide, shall be tested to simulate the actual use of the system in the normal operating environment. The successful completion of these operational scenarios shall be documented.

C. The system shall not be accepted until all requirements of system documentation and training have been completed.

END OF SECTION

SECTION 28 23 00

VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Network Video Management System (NVMS).
B. Video Storage Solution
C. Cameras and Accessories.
D. Video Printer.
E. Equipment Racks.
F. Cabling.

1.2 RELATED WORK

A. Section 26 05 33 - Conduit and Boxes
B. Section 26 05 13 - Wire and Cable
C. Section 27 15 00 – Horizontal Cabling Requirements
D. Section 28 05 00 - Basic Electronic Safety and Security System Requirements
E. Section 28 31 00 - Fire Detection and Alarm Systems
F. Section 28 13 00 - Electronic Access Control

1.3 QUALITY ASSURANCE

A. NVMS Software Developer (Manufacturer): The NVMS system shall be a single-source manufacturer such that the single manufacturer develops, supports, and warranties the NVMS software solution. The manufacturer shall have three (3) years documented experience.

1. The software developer shall be, at a minimum, a Microsoft Gold Certified Integrator and Partner for systems that reside in a Microsoft environment.

B. Integrator/Installer (Contractor): The Contractor must be a NVMS-certified installation, service, and support company specializing in the selected manufacturer's product, with demonstrated prior experience with the selected manufacturer's system installation and programming. The installer shall retain a Microsoft MCSE or equivalent technician for the purposes of server deployment, software configuration, and system integration.

1. The integrator must have local service representatives within 30 miles of the project site.

1.4 REFERENCES

A. NFPA 70 - National Electrical Code
B. Electronic Industries Association (EIA) Video Surveillance Equipment Standards
C. UL 2044 - Standard for Commercial Closed Circuit Television Equipment
D. UL 3044 - Standard for Safety for Surveillance Closed Circuit Television Equipment

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 28 05 00.

B. Product Data Submittal: Provide manufacturer's technical product specification sheet for each individual component type. Submitted data shall show the following:

1. Compliance with each requirement of these documents.

2. All component options and accessories specific to this project.

3. Electrical power consumption rating and voltage.

4. Heat generation for all power consuming devices.

5. All required wiring shall be identified.

6. Number of IP addresses that will be required from the Owner's Information Systems Department.

7. Statement of Acceptability of Designed Server:

    a. If the Contractor agrees that the server(s) designed and described herein is acceptable for the chosen manufacturer's solution and meets the demand of the application, this shall be stated in writing and submitted as part of the shop drawing submittal.

    b. If the Contractor does not agree that the server(s) designed and described herein is acceptable for the chosen manufacturer's solution, Contractor shall itemize the quantity, technical specifications, and capacities of the servers required to support the functionality and device quantities required by the project drawings. Indicate the capacity utilization factor for each server.

    c. Contractor's bid shall include any required changes in server(s) capacity.

8. Calculation for storage required using the criteria contained in the project drawings.

9. Calculation for required network bandwidth, including any latency restrictions.

10. Provide annual cost and all terms and conditions for the NVMS Software Maintenance Agreement. Include all additional costs and terms and conditions for any Annual Service Contracts provided by the Contractor for all services that are not included in the Software Maintenance Agreement.

C. System Drawings: Project-specific system CAD drawings shall be provided as follows:

1. Provide a system block diagram noting system components and interconnection between components. The interconnection of components shall clearly indicate all wiring required in the system. When multiple pieces of equipment are required in the exact same configuration (e.g., multiple identical cameras), the diagram may show one device and refer to the others as "typical" of the device shown.

D. Sample format of site specific programming guides to be used for system planning/programming conference with Owner.

E. Meeting agenda for planning/programming conference required in Part 3 of this specification.

F. Submit detailed description of Owner training to be conducted at project end, including specific training time.

G. Quality Assurance:

1. Provide materials documenting experience requirements of the manufacturer and installing contractor.

2. Provide system checkout test procedure to be performed at acceptance. Test procedures shall include all external alarm events.

H. Coordination Drawings:

1. Include all ceiling-mounted devices in composite electronic coordination files. Refer to Section 28 05 00 for coordination drawing requirements.

1.6 SYSTEM DESCRIPTION

A. This specification section describes the furnishing, installation, commissioning and programming of a complete, turnkey, closed circuit television system.

B. Performance Statement: This specification section and the accompanying project drawings are performance based, describing the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the equipment constraints described and the performance required of the system as presented in these documents, the vendor and the Contractor are solely responsible for determining all wiring, programming and miscellaneous equipment required for a complete and operational system.

C. Refer to the project drawings for model numbers for the Basis of Design for all equipment.

1.7 OWNER-SUPPLIED MATERIALS

A. Workstation, Servers, IT Switches

1.8 LICENSING REQUIREMENTS

A. All licenses required for system operation shall be included in the Contractor’s bid. Licenses shall include, but not be limited to, server and workstation software, cameras, encoders/decoders, and any other licensing that is required by the manufacturer for operation of any system component.

1. Camera licensing that is restricted to a particular device MAC address or in any way is only valid for a particular manufacturer or model number is not acceptable. Camera licenses shall be issued such that the Owner can replace a camera with another camera brand and/or model number and transfer the license from the old camera to the new camera at no additional cost at any future time. This license transfer procedure shall be capable of being performed by the Owner and shall not require the services of an integrator.

a. Exception: When a camera license is issued as a no-cost license in the limited condition that the NVMS manufacturer and the camera manufacturer are the same company, it is permissible to charge a future license fee to the Owner if the Owner elects to replace the NVMS manufacturer-branded camera with a third-party manufacturer's camera.

2. The Contractor shall fill out the NVMS Bid Inventory Form located herein and provide at the time of bid.

1.9 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 28 05 00.

B. Provide final system block diagram showing any deviations from shop drawing submittal.

C. Provide statement that system checkout test, as outlined in shop drawing submittal, is complete and satisfactory.

D. Provide final camera type and camera requirements schedules documenting all changes made during construction.

E. Warranty: Submit written warranty and complete all Owner registration forms.

F. Complete all operation and maintenance manuals as described below.

1.10 OPERATION AND MAINTENANCE DATA

A. Submit documents under the provisions of Section 28 05 00.

B. Manuals: Final copies of the manuals shall be delivered within 30 days after completing the installation test. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of the contractor responsible for the installation and maintenance of the system and the manufacturer for each piece of equipment for each system. The manuals shall have a table of contents and labeled sections. The final copies delivered after completion of the installation test shall include all modifications made during installation, checkout, and acceptance testing. The manuals shall consist of the following:

1. Hardware Manual: The manual shall describe all equipment furnished including:

a. General description and specifications.
b. Installation and check out procedures.
c. System layout drawings and schematics.
d. Alignment and calibration procedures.

2. Software Manual: The software manual shall describe the functions of all software and shall include all other information necessary to enable proper installation, testing, and operation. The manual shall include:

a. Definition of terms and functions.
b. System use and application software.
c. Graphical user interface use.
d. Reports generation.

3. Operator's Manual: The operator's manual shall fully explain all procedures and instructions for the operation of the system including:

    a. Computers and peripherals.
    b. System startup and shutdown procedures.
    c. Use of system.
    d. Recovery and restart procedures.
    e. Use of report generator and generation of reports.
    f. Data entry.
    g. Operator commands.
    h. Alarm messages.
    i. System permissions functions and requirements.

4. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.11 WARRANTY

A. Unless otherwise noted, provide warranty for one (1) year after Date of Substantial Completion for all materials and labor.

B. Onsite Work During Warranty Period: This work shall be included in the Contractor's bid and performed during regular working hours, Monday through Friday.

1. Inspections: Perform one minor inspection six-months after Substantial Completion and one major inspection prior to the expiration of the warranty.

2. Minor Inspections: Inspections shall include:

    a. Visual checks and operational tests of all equipment, field hardware, and electrical and mechanical controls.

    b. Mechanical adjustments if required on any mechanical or electromechanical devices.

    c. Install all available software updates, patches, or bug fixes available from the NVMS manufacturer.

3. Major Inspections: Inspections shall include all work described under paragraph Minor Inspections and the following work:

    a. Clean all equipment, including interior and exterior surfaces.

    b. Perform diagnostics on all equipment, including all system software diagnostics, and correct all diagnosed problems.

    c. Adjust all camera alignments that have become out of alignment from their documented position at Substantial Completion.

    d. Install all available software updates, patches, or bug fixes available from the NVMS manufacturer.

e. All warrantable system deficiencies during the Major Inspection shall be remedied under warranty at no cost to the Owner.

C. Operation: Upon the performance of any scheduled adjustments or repairs, verify operation of the NVMS system.

D. Emergency Service: The Owner will initiate service calls when the NVMS system is not functioning properly. Qualified personnel shall be available to provide service within the distance defined above. The Owner shall be furnished with telephone number(s) where service personnel can be reached 24/7/365.

E. Records and Logs: Keep records and logs of each task completed under warranty. The log shall contain all initial settings upon Substantial Completion. Complete logs shall be kept and shall be available for review on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the NVMS system.

F. Work Requests: Record each service call request on a service request form. The form shall include the model and serial number identifying the component involved, its location, date and time the call was received, specific nature of trouble, names of service personnel assigned to the task, instructions describing what must be done, the amount and nature of the materials used, the time and date work started, and the time and date of completion. Deliver a record of the work performed within five (5) days after work is accomplished.

G. System Modifications: Make any recommendations for system modification in writing to the Owner. No system modifications shall be made without prior approval of the Owner. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected. To the fullest extent possible, the Owner shall be provided with electronic restorable versions of all configurations prior to the modifications being made.

H. Software: Provide all software updates during the period of the warranty and verify operation in the system. These updates shall be accomplished in a timely manner, fully coordinated with NVMS system operators, shall include training for the new changes/features enabled, and shall be incorporated into the operations and maintenance manuals, and software documentation.

I. Refer to the individual product sections for further warranty requirements of individual system components.

1.12 SOFTWARE MAINTENANCE AGREEMENT/ANNUAL SERVICE CONTRACT

A. The Owner will enter into a contract directly with the vendor. This specification is not a contract between the Owner and the vendor to perform these services. The cost and terms of the SMA ***may*** be used by the Owner for NVMS solution selection.

PART 2 - PRODUCTS

2.1 NETWORK VIDEO MANAGEMENT SYSTEM – GENERAL REQUIREMENTS

A. The network video management system (NVMS) shall be an enterprise-class client/server based video security solution that provides management of digital video, audio and data across a TCP/IP network a commercial class PC-based software solution that provides management of digital video and data across a TCP/IP network.

B. Provide a turnkey solution that includes furnishing, installation, and configuration of a separate IP network, complete with all required network electronics, switches, and other hardware. The VMS shall utilize network switch ports provided by the Owner for all required IP connections. Provide the Owner with a complete list of all IP ports required.

C. ONVIF Compliance

1. The NVMS system shall be ONVIF certified as an ONVIF Network Video Client.

2. Cameras shall be ONVIF certified as an ONVIF Network Transmitter unless specifically noted as an exception to this requirement in the project drawings.

D. The NVMS system shall be an "open system."

1. To meet this requirement, the NVMS must directly support cameras from a minimum of three (3) readily available camera manufacturers.

2. The three (3) camera manufacturers must have no corporate relationship to the NVMS manufacturer.

3. "Directly support" shall be defined as plug-n-play using drivers that are commercially available at the time of bid.

4. In addition to the requirement to support three (3) independent manufacturer's cameras, the NVMS may support an unlimited additional quantity of in-house or other proprietary cameras.

5. The open system shall not require proprietary storage solutions. It shall support third party storage solutions, including:

a. Commercially available Direct Attached Storage (DAS) devices.

b. Network Attached Storage (NAS) devices.

c. Storage Area Networks (SAN) for ***primary*** or archival storage purposes. Primary support for SAN shall be defined as:

1) The ability to directly record to SAN device without first recording to an NAS or DAS.

2) The NVMS is provided with a user experience that makes the video recorded to the SAN transparent to the user. This shall be defined as:

a) Full search, bookmarking, and other software features for finding, marking, locating, and identifying video are supported by the NVMS for video recorded to a SAN in an identical way to video that is recorded to an NAS or DAS.

b) No loading of the video from the SAN into the NVMS shall be required.

c) Full playback, windowing of camera video, archiving, and exporting is supported by the NVMS for video recorded to the SAN in an identical way as video recorded to an NAS or DAS.

6. The system must have a published API/SDK permitting third party integrations to the product without restrictions.

7. The NVMS shall support active directory using LDAP protocol.

E. The NVMS system shall consist of the following hardware/software components:

1. Software:
   a. Server and client
   b. Recording services, archival services, and storage management
   c. Configuration tools

2. System storage as specified on the project drawings.

3. Cameras and related hardware as specified on the project drawings.

4. Hardware: Servers, workstations, and miscellaneous hardware (keyboard, mouse, KVM) as specified on the projects drawings.

5. Network electronics and related hardware and software as specified on the project drawings.

F. Video from any camera on the system (on the LAN, WAN or Internet) shall be capable of being viewed from single or multiple workstations simultaneously at any time, limited only by network bandwidth.

G. The NVMS shall support simultaneous displaying of live (30 fps) video of a minimum of 16 cameras while the video monitoring screen is configured in a 16-camera split configuration. In no case shall the frame rate of the camera be required to be restricted to less than 30 fps to display a 16-camera split view.

H. Simultaneous display and recording of every camera shall be supported with independent user-adjustable frame rates that can be set differently for the display stream and the recording stream. These independent settings shall be unique per camera.

I. The NVMS monitoring software shall support any combination of recorded and live video in any multiple camera split view, including viewing recorded video and live video from the same camera.

J. The NVMS shall support continuous recording and event-based recording simultaneously. This shall be capable of being set on a per camera basis.

K. Viewing of video (live and recorded) shall be possible from client software from any client hardware that is connected to the security LAN/WAN or Internet (through appropriate firewalls). In addition, system administration shall be permitted from remote client hardware.

2.2 NVMS MANUFACTURERS

A. Basis of Design: Genetec
B. ONSSI
C. Milestone

2.3 NVMS SERVER REQUIREMENTS

A. The NVMS shall operate on the Windows 2008 Server Operating System. The server software shall be a multi-tasking, multi-threading application system architecture designed specifically for the Windows environment.

B. The server shall communicate on a TCP/IP based Ethernet LAN capable of utilizing 100/1000BaseT.

C. The server shall be provided by the Owner.

D. The server(s) requirements have been calculated based on the NVMS Basis of Design manufacturer noted above. By submitting a bid, the Contractor acknowledges that the calculated server requirements listed here may not be sufficient for a listed alternate, acceptable manufacturer selected by the Contractor. The Contractor shall modify the calculated server requirements listed herein based on the calculated requirement of the chosen manufacturer. The server requirements for the basis of design are as follows:

1. Server Quantity and Location: Refer to project drawings for quantity of servers required and their location.

2.4 NVMS CLIENT REQUIREMENTS

A. The NVMS PC workstation(s) shall be provided by the Owner.

2.5 NVMS SYSTEM DETAILED REQUIREMENTS

A. Network Requirements: The NVMS shall support Ethernet 10/100 BaseT and Gigabit Ethernet.

1. Network protocols shall be supported including TCP/IP, IPX, and UDP.

2. The network interface shall allow remote access of the NVMS from anywhere on the end-user's LAN/WAN or Internet (behind firewall).

3. The system shall permit limiting of frame rate transmission to individual clients.

4. Both Multicast and Unicast shall be supported.

5. All transmission of system data shall be secured using Secure Socket Layer (SSL) security on the TCP/IP network.

6. Simple Network Management Protocol (SNMP) shall be supported.

B. Video Formats:

1. The NVMS shall support MPEG-4, and H.264 compression formats.

2. The system shall support any single stream of bandwidth up to 90Mbit/sec at 30 fps at 4872 x 3248 resolution with no system performance degradation, assuming appropriate network bandwidth.

3. Video shall be recorded using a 256-bit encryption algorithm with authentication (watermarking) software suitable for evidentiary proceedings. The watermarking feature shall provide evidence of altered video.

    a. The video shall be watermarked with the authentication key/signature during recording of live video to the drive.

    b. A video player shall be provided with the NVMS system.

        1) The player shall have the ability to validate the authentication upon playback.

        2) This authentication shall provide the storage media name, camera name, video time, and user information.

        3) The authentication shall have the ability to be password protected.

4. Resolution:

    a. The camera resolution shall be user selectable on a per-camera basis. Selecting or changing resolution shall not require a restart of the application, server, or workstation.

    b. The system shall support the following resolutions:

        1) NTSC Resolutions: 0CIF (176 x 120), CIF (352 x 240), 2CIF (704 x 240), 4CIF (704 x 480).

        2) VGA Resolutions: QVGA (320 x 240), VGA (640 x 480), SVGA (800 x 600), XVGA (1024 x 768), 4xVGA (1280 x 960).

        3) Megapixel Resolutions: SXGA (1280 x 1024: 1.3MP), SXGA + EXGA (1400 x 1050: 1.4 MP), UXGA (1600 x 1200: 1.9MP), WUXGA (1920 x 1200: 2.3MP), QXGA (2048 x 1536: 3.1MP), WQXGA (2560 x 1600: 4.1MP), QSXGA (2560 x 2048: 5.2MP), 3296 x 2472: 8MP, 4000 x 2672: 11MP, 4864 x 3248: 16MP, 6576 x 4384: 29MP.

            a) 16:9 and 4:3 formats shall be supported.

        4) HDTV Resolutions: 720p, 1080(i/p) in 16:9 format.

C. Remote Clients:

1. The NVMS system shall include the ability to view live video or playback recorded video over the LAN/WAN or the Internet from any PC. This function shall NOT require any installed client software. An industry standard Web Browser (e.g., Internet Explorer, Firefox, Chrome) shall be the only software required to view non-authenticated video from a remote PC.

a. Any plug-ins (e.g., ActiveX, Java, Flash) required to view remote video shall be capable of being pushed to the user's PC at the time of initiating the remote video viewing session.

b. Remote viewing shall be supported whether the remote client is:

1) Inside the firewall containing the NVMS.
2) Outside the firewall containing the NVMS.
3) Accessing the NVMS through a VPN.

2. Remote Client Features:

a. Display live video.

b. Digital zooming and panning of fixed cameras.

c. PTZ camera control in real time, including adjusting PTZ lock and dwell times.

d. Ability to access video from all accessible recording devices.

e. Priority-based camera control takeover.

f. Customizable camera viewing screen split configurations that are retained under the user login between remote client sessions.

D. Mobile Clients (Apps):

1. The NVMS shall include a mobile video viewing application for the operating system.

a. The iOS application shall be a single universal application supporting both the iPhone 4s and iPad 2 resolutions. An iPhone application that scales up for use on the iPad using the iPad 1x/2x feature is not acceptable.

b. The Android application shall be a universal application that supports Android smartphones and Android tablets. The Android application shall support Android codeset name Ice Cream Sandwich and may require a minimum installed codeset of Gingerbread.

2. Features:

a. The mobile client shall permit viewing of live video or playback of recorded video.

b. Split screen video display shall be supported. The split screen shall permit live and recorded video simultaneously in the screen split. The screen split layout shall be retained between mobile client sessions.

c. Provide time synchronization of the video of different cameras to account for mobile network latency to ensure that live video from multiple cameras is time synchronized.

d. The mobile client shall be optimized with video compression to support video viewing on mobile networks. The mobile client shall maintain a minimum of 7 fps per camera on a mobile network performing at 200 Kbit/s with a latency of 200ms.

e. All transmission of system data shall be secured using Secure Socket Layer (SSL) security at a minimum.

3. Licensing:

a. Provide licensing for 1 iOS mobile clients.
b. Provide licensing for 1 Android mobile clients.

E. Workstation Client Software Requirements:

1. The client software for the NVMS shall run as an application on Windows 7 64-bit. The client software shall not require a PC more robust than that defined above in the section entitled "NVMS CLIENT REQUIREMENTS." Should the workstation client software require a PC configuration more robust than that defined herein, the cost of upgrading the workstation hardware to the more robust requirement shall be paid by the Contractor.

2. Licensing:

a. Provide licensing for 2 concurrent clients on the system.

3. The client software shall provide video signal detection and provide alerts whenever video is lost on any input channel.

4. Updates to the client software shall be capable of being pushed to all clients from the NVMS server.

5. The client software shall provide a graphical mapping feature. The graphical map shall accommodate the importation of CAD files, or custom development of floor plans or site plans to create a to-scale or not-to-scale graphical representation of the system layout including all cameras.

a. Cameras located on the graphical map shall be "live," which is defined as the ability to click the camera in the graphical user interface (GUI) to see camera information and live video. The camera name shall be available to the user via a "mouse hovering" maneuver over the camera icon.

b. For site cameras, the graphical map shall consist of an overall site plan showing all exterior cameras. Buildings and other physical entities on the site shall be graphically represented.

1) The buildings shown on the site plan shall visually indicate to the user that cameras are located inside that building's interior, if applicable.

c. The user shall be able to click a building that contains cameras to obtain a new graphical layout of that building. Once the building interior layout graphical map is on screen, interior cameras shall be represented by icons.

d. The user shall have the ability to navigate back to the main (previous) graphical map via a single-click graphical icon.

6. Camera Configuration:

a. Each camera shall be configurable for a 32-alphanumeric character name.

b. The system shall allow for the setup and adjustment of brightness, contrast, archiving, motion detection, and Pan/Tilt/Zoom on a per camera basis.

c. The NVMS shall support a separate frame rate for recording and a separate frame rate for viewing for every camera input (assuming the camera provides two streams). These frame rates shall be capable of being independently set for each camera input.

d. The NVMS shall support the PTZ control of analog NVMS cameras through the encoders.

e. The compression algorithm formats MJPEG and MPEG4 shall be supported in the same system and shall be individually selectable on a per-camera basis.

f. Each individual camera shall be capable of having individual camera settings that shall include (at a minimum):

1) Continuous recording.

2) Motion-based recording capability shall be provided including:

a) Motion as determined by the NVMS software using:

(1) Entire screen motion detection
(2) User defined area triggers

b) Motion as determined at the camera.

c) Motion trigger by digital inputs from external trigger systems such as contact closures, alarm inputs, POS integration, etc.

(1) Motion triggers received by external trigger inputs shall be recorded by the event recording capabilities of the NVMS and identifiable on a timeline during playback and in reports.

3) Alarm-initiated recording.

a) When a camera enters alarm recording mode, the NVMS shall have the capability of changing to different camera settings for the recorded video during the duration of the alarm mode. The settings capable of being changed shall include the frame rate and the resolution. These setting changes shall be configurable in advance per camera by the User through the software GUI.

4) Time-based recording on a preset schedule.

5) Manual (user) activation of the start and stop of the recording process through the GUI.

a) The NVMS software shall prevent any user from manually starting and stopping the recording of video based on that user's login credential.

6) Defined pre-event and post-event recording buffers shall be provided for all non-continuous recording events.

7) Each camera shall be capable of having unique storage retention settings.

F. Software Security Requirements:

1. All users shall be capable of being authenticated against Active Directory using LDAP, before being granted system access. Should the Owner not use Active Directory, the NVMS shall provide a built-in login and credential management tool to permit rules-based access rights on a per-user basis.

2. The access rights shall be selectable on a per-user basis. In addition, user groups shall be capable of being assigned whereby each user group has a common set of access rights. Users shall be capable of being assigned to these user groups by the system administrator.

3. Access rights available for customization shall include:

a. Live Video Viewing:

1) Use of PTZ controls.
2) Start and stop of manual recording.
3) Access to and exclusive from individual cameras and monitors.
4) Access to system settings.
5) Ability to define video blocking positions of PTZ cameras for certain users.

b. Viewing Recorded Video:

1) Ability to export recorded video. including email.
2) Access to system archiving and backup.
3) Ability to watch recorded video from individual cameras.
4) Ability to delete recorded video.

c. Camera Setup:

1) Add or remove cameras from the system.
2) Change camera settings including resolution and frame rate.
3) Change motion detection and other defined triggers.

d. General Settings:

1) Change client software settings.
2) Ability for user to configure or change custom viewing screen configurations.
3) Modify server settings.
4) Change recording or bandwidth settings.
5) Configure users.
6) Access and configure external messaging capabilities.
7) View, print, save and clear the system log.

G. Pan/Tilt/Zoom (PTZ) Control:

1. The NVMS shall support PTZ control from any client, including remote and mobile clients.

2. The following PTZ features shall be supported:

a. Priority Levels
b. Device Group Control
c. PTZ Override (Lockout)
d. Proportional PTZ Control
e. Preset Lock via video screen
f. Preset Tour

H. Video Archiving:

1. The archiving feature shall be hardware independent, providing the ability to utilize commercial off-the-shelf mass storage devices as archived video destinations, including optical DVD, DAS, NAS, SAN, and other external storage drives.

2. The archiving software shall provide the ability to manage and store video information from multiple recorded video locations to a central location.

3. Each NVMS server shall have the ability to set its own unique archiving settings. Video shall automatically be archived based on user-defined "percentage full" settings. When the NVMS reaches the designated capacity threshold, video shall be automatically copied to the archive storage destination, and space on the source of the recorded video shall be released for overwrite by new video information using a first-in, first-out algorithm.

a. Exception: Video marked or tagged by the user or by automated alarm inputs shall be retained by the archiving process despites its location in the first-in, first-out timeline.

4. Regardless of the video's storage location (local or in the archive), the NVMS software shall automatically retrieve video associated with an event on demand by the user in response to a search, browse, or other retrieval action. The actual storage location of the video shall be transparent to the user.

a. Exception: Video archived to removable media (e.g., removable hard drives or optical DVD) shall require prompting to the user to insert the appropriate media.

5. Archiving shall be capable of being scheduled such that archiving will only run during certain hours defined by the Owner.

6. The NVMS solution shall be permitted to utilize advanced algorithms for managing onboard storage such as reducing the frame rate of recorded video for the oldest video as an alternative to completely removing the video using a first-in, first-out algorithm. If this option exists in the NVMS software, it must have the following features:

   a. Ability of the Owner to completely disable the feature.
   b. Ability to set a minimum frame rate that the system will not exceed.
   c. Ability to set the feature on a per-camera basis.

I. Video Viewing Layouts:

1. The NVMS shall support the ability to save the list of camera views currently being displayed, along with the currently selected template, with a user-defined name to be loaded as needed by the system operator.

2. System operators shall have the ability to define multiple viewing templates that can be recalled and configured on an as-needed basis.

3. This feature shall be subject to the access rights provided by the system administrator through their login credential.

J. Still Image Capture/Save:

1. During playback or monitoring of video, the system shall have the ability to create and save a still picture. This operation shall not affect any other operation and shall not alter the recorded video. The file format shall be an industry standard format (JPEG, TIFF) allowing for file transfer via e-mail, printing, or file transfer to other media.

2. This feature shall be subject to the access rights provided by the system administrator through their login credential.

K. Export Video Clip to File:

1. The NVMS shall have to ability to save and export recorded video to a file (MPEG, AVI) for sharing and reviewing video clips. The start and end times for each video segment shall be user defined. The exported video clip shall be viewable via a standard Windows media player.

2. This feature shall be subject to the access rights provided by the system administrator through their login credential.

L. Automated Motion Video Searching:

1. The system shall support advanced automated motion video searching against pre-recorded video. The automated motion video search shall analyze frames in a video segment to detect motion activity from image to image. It shall display thumbnail images of the frames with activity, complete with a histogram depicting the relative amount of activity within each frame.

2. The search shall be defined by selecting a specific camera and a specific time period in which the suspected activity took place. All motion events associated with that camera and time period shall be displayed in either a trace or thumbnail format for review.

3. Motion shall be capable of being restricted to any user-defined area of the screen as drawn by the user using a windowing tool in the software.

M. Video System Analytics (VSA):

1. The NVMS shall provide an embedded Video System Analytics solution.

2. The result of a trigger of an VSA shall be user definable and shall include:

a. Marking video.

b. Adjusting recording characteristics including frame rate and resolution.

c. Activating changes in the monitoring of cameras, including showing full screen video of the triggered camera.

d. Providing screen prompting to the system operator.

3. The set of Intelligent Video Analysis algorithms shall provide the following functionality:

a. Alert Types:

1) Smart Video Motion Detection. This VSA shall have algorithms to filter out minor vibrations. The sensitivity of this filter shall be user adjustable. This VSA shall also provide motion masking where the user can define an area of the frame where motion will be ignored.

2) Camera Tampering. When the VSA detects a camera is moved from its original position, when the camera view is obstructed, or when the focus is changed, this VSA shall activate.

3) Sudden Change in Light Intensity. This VSA shall trigger when there is an extreme change in ambient light – light to dark or dark to light. The sensitivity of this VSA shall be user definable.

4) New Object in Scene. This VSA shall detect an object that was not present when the VSA originally learned the scene or that has been inserted into the scene in a user defined area in the field of view.

5) Object Removed from Scene. When an object that was present when the VSA originally learned the scene view has been removed from the scene, this VSA shall activate. This VSA shall be capable of being applied to a window of the total field of view as defined by the user.

6) Specific Object Detected in Scene. This VSA shall trigger when an object is detected that is defined by specific properties including people, automobiles, or an object of a specific color.

7) Congestion in Defined Area. This VSA shall occur when the VSA detects congestion in a specific area of the scene as defined by the user.

8) Directional Motion VSA shall occur when the VSA detects an object moving in a direction specified in the setup of this feature.

9) Object Crosses a Defined Region. This VSA shall detect an object moving across a virtual boundary or into a defined area from a specified direction.

10) Moving Object Stops. This VSA shall detect when a moving object in the scene ceases to move.

11) Static Object Starts to Move. VSA shall occur when the VSA detects when a static object in the scene starts to move.

12) Object Moves Too Fast. This VSA shall trigger when an object is moving faster than a pre-defined speed.

13) Loitering. This VSA shall detect when a person or group of people in the scene slows down or ceases to move for a specified period of time.

14) Detection of a Human Face. This VSA shall trigger when the VSA detects a frontal view of a human face.

15) People Counting. This VSA shall be used when a camera is positioned in a top-down view of an entry/exit portal. This feature shall provide an alarm with a positive count for entry and a negative count for exit.

b. The VSA shall support the ability to store the graphical output for a specific event for use with VSA alarms. This feature shall allow the graphical output of a specific event to be stored as a file and later used as an overlay to be used and associated with an alarm for historical searching.

c. The VSA shall support CIF, 4CIF, and D1 video resolutions during video processing.

d. The VSA shall support video infrared imaging.

N. The NVMS shall provide up to 10 different and independent programmable recording schedules.

1. The schedules may be programmed to provide different record frame rates for day, night, and weekend periods, as well as holidays and exception days.

2. Advanced task schedules may also be programmed that could specify allowed log-on times for user groups, when events may trigger alarms, and when data backups and archiving should occur.

O. The VMS shall support Dual Authorization logon. It shall function as follows:

1. Dual Authorization user groups may be created.

2. Logon pairs, consisting of any two normal user groups, may be assigned to each Dual Authorization user group.

3. A separate set of privileges and priorities can be assigned for each Dual Authorization user group.

4. For each user group assigned as part of a logon pair, it shall be configurable whether the group can:

a. Log on either individually or as part of the logon pair.
b. Log on only as part of the logon pair.

5. If a user that is part of logon pair logs on individually, then the user shall receive the privileges and priorities of the user's assigned user group. If the same user logs in as part of a logon pair, then the user shall receive the privileges and priorities assigned to the Dual Authorization group to which the pair is assigned.

P. The NVMS shall auto-discover cameras and encoders. Device detection shall support devices in different subnets.

Q. The NVMS shall be designed in such a way that server downtime or loss of communication to the server does not affect the functionality of the recording services. Normal recording and motion recording shall continue during server downtime.,

2.6 NVMS RECORDING REQUIREMENTS

A. The NVMS shall provide management of the recording and playback of video, audio, and data (bookmarking, alarm data, etc.).

B. Refer to the Camera Schedules on the project drawings for specific variables to be used on a per-camera basis for the purpose of calculating storage capacity and retention.

1. Total distributed storage requirements shall be determined based on a minimum of 30 days storage retention.

2. Cameras, unless otherwise noted on the Camera Schedule(s), shall be assumed to be recording 24 hours per day, 7 days per week, 365 days per year. Specific per-camera assumptions stated on the Camera Schedule for percent motion shall be used in the storage calculation.

3. Compression shall be permitted to be used in the storage calculation. The compression algorithm (MPEG-4, H.264, etc.) shall be used on a per-camera basis. If the NVMS permits variable levels of compression intensity, the use of the "average" or "medium" level setting shall be used in the storage calculation unless otherwise noted.

4. The Contractor shall provide the complete storage analysis and calculation as a shop drawing.

C. Network Video Recorder (NVR) Hardware Platform:

1. The NVR shall be defined as a storage device for recording IP video streams from IP cameras or from analog cameras that have been encoded to IP. In both cases, the NVR shall record IP streams from cameras or encoders located anywhere on the IP network without being direct-cable connected to the NVR.

2. Refer to the project drawings for specific requirements, model numbers, and basis of design for the NVR.

3. NVR Configuration:

a. The NVR shall contain one hard drive for the operating system and software, and all hard drive storage required to achieve the required storage retention.

4. The NVMS shall provide a failover function where an NVR can be assigned as a backup to other NVRs. When an assigned NVR goes out of service, the failover NVR takes over the responsibilities of the failed NVR. When the primary NVR returns to service, the control shall be automatically transferred back to the primary NVR.

5. It shall be possible to assign a redundant NVR to every NVR for use in normal operation of all NVR(s) in the system. The redundant NVR shall record the same streams as the primary NVR. The redundant NVR shall have its own disk drives where it shall store the recorded data.

a. It shall be possible to view the data recorded by the redundant NVR in the client software. The redundant NVR shall have camera symbols that can be placed in the camera selection tree. These cameras shall have the same name as the cameras of the primary NVR. An indication shall be provided to indicate that the camera names are located on the redundant NVR.

D. Additional Integration Requirements:

1. Relays from devices connected to the system shall be controllable from command scripts, the NVMS SDK, and icons on the user interface.

2. Input and relay state changes from devices connected to the system shall be recognizable as events in the NVMS.

3. The video management system shall be capable of monitoring third party equipment using SNMP and Rmon protocols.

4. The video management system shall provide a command script interface that allows system operations to be programmatically controlled.

a. The system shall provide a built-in editor for the creation of the command scripts.

b. The system shall be configurable such that operators can execute the created scripts by double-clicking on representative icons in a logical tree or site map.

c. The system shall be configurable such that the created scripts can be executed automatically in response to a system event. The automatic event-driven execution shall optionally be schedule-dependent.

d. The system shall be configurable to execute a user-group dependent command script on user logon.

e. The system shall be configurable to execute an alarm-dependent command script on user acceptance of the alarm.

5. The video management system shall provide a software interface that allows third-party software to generate events in the video management system. The software shall support any COM programming languages (e.g., Visual Basic and C++), any .Net programming language (e.g., C#) or JavaScript.

6. The NVMS shall allow third-party software to include up to 10 data fields and an alarm ID, along with the virtual input event.

a. These fields shall be searchable in the system logbook.

b. The virtual input data shall be capable of being displayed in playback mode synchronously with the associated video.

E. SDK Integration:

1. The video management system shall provide a documented Software Development Kit (SDK) to allow integration with third-party software.

2. The SDK shall expose all functionality of the command scripts, including, for example:

a. Control of operator workstation image window layout
b. Sending messages to specific workstations
c. Assignment of cameras, documents, URLs, and maps to operator client workstation image panes
d. Assignment of cameras to analog monitors connected to encoders
e. Dome control
f. Alarm generation
g. Recording mode control
h. Exporting of recorded data
i. Relay control

3. SDK functionality shall be password protected.

4. The SDK shall be accessible from all .Net programming languages.

F. OPC Server:

1. The VMS shall provide an OPC server for integration into third-party software systems, such as building management systems.

2. The OPC interface shall follow the OPC Alarms and Events standard.

2.7 NVMS CABLING

A. Refer to Division 27 for all cabling requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with the manufacturer's instructions and recommendations for installation of all products.

B. Provide all system wiring between all components as shown on the project drawings or as directed by the manufacturer, whichever is the more stringent requirement.

C. Mount all cameras in the approximate locations shown on the drawings. Coordinate installation with other trades and utilities in the vicinity. Cameras containing fixed lenses, moved by more than 1'-0" from their location shown on the drawings, shall have a new lens calculation performed by the Contractor. Provide Architect/Engineer with results of lens calculation before proceeding with installation.

D. Coordinate with Owner's IT Department to acquire network connections as well as any network configuration information, such as IP numbers, that will be required to connect NVMS to Owner network (if applicable).

E. Provide all low voltage and +120 VAC power to all devices as required for proper system operation. Refer to Sections 26 05 33 and 26 05 13 for further requirements.

F. All low voltage security wiring shall be routed and supported separately from all other telecommunications cabling.

G. Cabling shall be plenum rated when installed outside of conduit in plenum ceilings.

3.2 FIELD QUALITY CONTROL

A. Where these specifications require a product or assembly without the use of a brand or trade name, provide a product that meets the requirements of the specifications as supplied and warranted by the system vendor. If the product or assembly is not available from the system vendor, provide product or assembly as recommended by the system vendor.

B. Periodic observations will be performed during construction to verify compliance with the requirements of the specifications. These services do not relieve the Contractor of responsibility for compliance with the project drawings.

C. It shall be the Contractor's responsibility to correct all inadequate picture quality issues prior to acceptance of the system.

3.3 MANUFACTURER'S FIELD SERVICES

A. Installation shall be performed by a factory-trained and certified Contractor.

1. Provide a comprehensive, site-specific customer planning guide for the system. Conduct a conference with the Owner prior to any installation to discuss the

programming options of the system and the planning guide. The result of this planning guide shall be the determination of the system options for each device and for the software.

B. Include labor for all planning and all programming activities required to implement the Owner's operational preferences for each device and software. Any software programmable option, within the bounds of the capabilities of the hardware specified, shall be included.

C. Provide a complete, functional system as described by the project drawings. These responsibilities include:

1. Complete hardware setup, installation, wiring, and software configuration of the system, including all remote operator locations and all peripheral hardware.

2. Complete programming of all hardware and software options in accordance with the Owner's preferences as determined by the planning guide conference.

3. Programming of all custom graphic GUI screens including devices.

4. Complete system diagnostic verification.

D. Provide an authorized manufacturer representative to commission the system and ensure that facility-wide standards and project setup procedures are adhered to.

3.4 SYSTEM ACCEPTANCE

A. Submit for review a formal acceptance and system checkout program. The system checkout procedures shall include all system components and software. Perform the tests and document all results under the supervision of the manufacturer's system engineer.

B. All operational scenarios, as defined by the customer planning guide, shall be tested to simulate the actual use of the system in the normal operating environment. The successful completion of these operational scenarios shall be documented.

3.5 SYSTEM DOCUMENTATION

A. Complete documentation shall be provided for the system. The documentation shall describe:

1. All operational parameters of the system.
2. Complete documentation of all programming and options.
3. Complete operating instructions for all hardware and software.

B. The following sections shall be provided in the system documentation:

1. System Administrator Manual: Provides an overview and a step-by-step guide and instructions detailing all system administrator responsibilities and functions.

2. User Manual: A step-by-step guide and instructions detailing all system user functions.

3. Technical Maintenance Manual: A comprehensive document providing all maintenance actions, system testing schedules, troubleshooting flowcharts, functional system layout, wiring diagrams, block diagrams, and schematic diagrams.

3.6 SYSTEM TRAINING

A. All labor and materials required for on-site system training by a certified representative of the system manufacturer shall be provided. Training shall be conducted at the project site using the project equipment.

B. Provide two weeks advanced notice of training to the Owner.

C. Provide a training outline agenda describing the subject matter and the recommended audience for each topic.

D. At a minimum, the following training shall be conducted:

1. System Administrators: A course detailing the system functions and operations. Provide configuration training on all aspects of the system.

2. Users: Provide a detailed course outlining the operational features of all aspects of the user interface. Topics shall include alarm monitoring functions, reports, error handling, alarm handling, output relay control, and general overview of the report hardware.

3. GUI Editing: Conduct detailed training on using the GUI editing software. Topics shall include the editing of existing graphical maps and the creation of new graphical maps.

E. Minimum on-site training times shall be:

1. System Administrators: One (1) days.
2. Users: One (1) day.
3. GUI Editing: One (1) day.

END OF SECTION

NVMS Bid Inventory Form

Item	Cost/Other
Total fixed (lump sum cost) for the entire project:	
Itemize the total fixed lump sum cost as follows:	
• Software cost for NVMS including all implementation services.	
• Cost for all camera hardware and associated accessories.	
Itemize software cost for the following (show the math):	
• Fixed, non-reoccurring flat base cost (if any)	
• Fixed, non-reoccurring per-camera licensing fee (if any)	
• Recurring flat base cost (if any – do NOT include optional software maintenance agreement costs)	
• Recurring flat per-camera licensing fee (if any)	
• Client workstation licensing fees (if any)	
• Remote Client licensing fees (if any)	
• Mobile Client licensing fees (if any)	
• Itemize all other license fees not included above.	
Add all required and optional software maintenance agreement costs (do NOT include in bid cost).	
Acknowledge receipt of addenda by writing addendum number to the right.	_____ through _____ inclusive

Include below Server Acknowledgement Statement per Section 28 23 00, Article 2.3, Paragraph D.
List below all separate software options, licensing or other monetary features that the Integrator interprets as *not* being requested by this RFP, but that are available from the NVMS manufacturer for purchase. Attach separate document if needed.

SECTION 28 31 00

FIRE ALARM AND DETECTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fire alarm and detection systems

1.2 RELATED WORK

A. Section 26 05 53 – Electrical Identification: Refer to electrical identification for color and identification labeling requirements.

1.3 QUALITY ASSURANCE

A. Manufacturer: Company specializing in smoke detection and fire alarm systems with ten years' experience.

B. Installer: A factory-authorized licensed electrical or security contractor with five years' experience in the design, installation and maintenance of fire alarm systems by that manufacturer.

C. Qualifications: The person managing/overseeing the preparation of shop drawings and the system installation/programming/testing shall be trained and certified by the system manufacturer and shall be Fire Alarm Certified by NICET, minimum Level 2. This person's name and certification number shall appear on the start-up and testing reports.

1.4 REFERENCES

A. NFPA 70 - National Electrical Code
B. NFPA 72 - National Fire Alarm and Signaling Code
C. NFPA 101 - Life Safety Code
D. UL 2017 – General Purpose Signaling Devices and Systems

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00 and as noted below.

1. Failure to comply with all the following and all the provisions in 26 05 00 will result in the shop drawing submittal being rejected without review.

2. Failure to submit the fire alarm without all requirements fulfilled in a single comprehensive submittal will be grounds to require a complete resubmittal.

B. Provide product catalog data sheets as shop drawings.

1. Provide a product catalog data sheet for each item shown on the Electrical Symbols List and for each piece of equipment that is not shown on the drawings, but required for the operation of the system.

2. Where a particular Electrical Symbols List item has one or more variations (such as those denoted by subscripts, etc.) a separate additional product catalog data sheet shall be provided for each variation that requires a different part number to be ordered. The corresponding Electrical Symbols List symbol shall be shown on the top of each sheet.

3. Where multiple items and options are shown on one data sheet, the part number and options of the item to be used shall be clearly denoted.

C. Submit CAD floor plans as shop drawings:

1. The complete layout of the entire system, device addresses, auxiliary equipment, and manufacturer’s wiring requirements shall be shown.

2. A legend or key shall be provided to show which symbols shown on the submittal floor plans correspond with symbols shown on the Contract Documents.

D. About all fire alarm circuits, provide the following: manufacturer’s wiring requirements (manufacturer, type, size, etc.) and voltage drop calculations.

E. Provide installation and maintenance manuals under provisions of Section 26 05 00.

F. Submit manufacturer's certificate that system meets or exceeds specified requirements.

G. Provide information on the system batteries as follows: total battery capacity, total capacity used by all devices on this project, total available future capacity.

H. Submit photocopy proof of NICET certification of the person overseeing the preparation of drawings and installation/testing.

I. When required to comply with local or state regulatory reviews, the fire alarm submittal shall have a Professional Engineer’s stamp and signature of the state in which the project is completed. NOTE: The Architect/Engineer cannot stamp and seal submittal drawings not prepared under their supervision.

1.6 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide quantity equal to 2 percent (2%) of amount of each type installed, but no less than two (2) units of each type.

a. Smoke and heat detectors, manual pull stations, duct smoke detectors, monitor modules, control modules and relays.

b. Notification appliances: Speakers, speaker strobes, and strobes.

2. Keys: The installing contractor shall collect all equipment spare keys provided with each lockable or resettable device/cabinet [minimum of one (1) set each] and shall turn over to the Owner upon completion.

3. All spare parts shall be housed in metal cabinet labeled “Fire Alarm Spare Parts.”

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Store and protect products under provisions of Section 26 05 00.

1.8 REGULATORY REQUIREMENTS

A. System: UL or FM Global listed.

B. Conform to requirements of NFPA 101.

C. Conform to requirements of Americans with Disabilities Act (ADA).

D. Conform to UL 864 Fire Alarm, UL 1076 Security, UL2017 General Signaling, and UL 2572 Mass Notification Communications.

1.9 SYSTEM DESCRIPTION

A. Performance Statement: This specification section and the accompanying fire alarm specific design documents describe the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the equipment described and the performance required of the system, as presented in these documents, the Vendor and the Contractor are solely responsible for determining all wiring, programming and miscellaneous equipment required for a complete and operational system.

B. This section of the specifications includes the furnishing, installation and connection of the microprocessor controlled, intelligent reporting, fire alarm equipment required to form a complete coordinated system that is ready for operation. It shall include, but is not limited to, alarm initiating devices, control panels, auxiliary control devices, annunciators, power supplies, and wiring as indicated on the drawings and specified herein.

C. Fire Alarm System: NFPA 72; Automatic and manual fire alarm system, non-coded, analog-addressable with automatic sensitivity control of certain detectors, multiplexed signal transmission.

D. System Supervision: Provide electrically supervised system, with supervised Signal Line Circuit (SLC) and Notification Appliance Circuit (NAC). Occurrence of single ground or open condition in initiating or signaling circuit places circuit in TROUBLE mode. Component or power supply failure places system in TROUBLE mode.

E. Alarm Reset: Key-accessible RESET function resets alarm system out of ALARM if alarm initiating circuits have cleared.

F. Lamp Test: Manual LAMP TEST function causes alarm indication at each zone at fire alarm control panel and at annunciator panels.

G. Drawings: Only device layouts and some equipment have been shown on the contract drawings. Wiring and additional equipment to make a complete and functioning system has not been shown, but shall be submitted on the shop drawings.

1.10 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 26 05 00.

B. Include location of end-of-line devices.

C. Provide a CAD drawing of each area of the building (minimum scale of 1/16" = 1'-0") showing each device on the project and its address. The devices shall be shown in their installed location and shall be labeled with the same nomenclature as is used in the fire alarm panel programming.

D. Submit test results of sound pressure level (dBA) with the rooms tested designated on the floor plan. Notification devices shall have the tap wattage designated.

1.11 OPERATION AND MAINTENANCE DATA

A. Submit data under provisions of Section 26 05 00.

B. Include operating instructions, and maintenance and repair procedures.

C. Include results of testing of all devices and functions.

D. Include manufacturer's representative's letter stating that system is operational.

E. Include the CAD floor plan drawings.

F. Include shop drawings as reviewed by the Architect/Engineer and the local Authority Having Jurisdiction.

1.12 DOCUMENT STORAGE CABINET

A. The cabinet shall have all fire alarm system documents, including record drawings, wiring diagrams, operation manuals, etc. A legend sheet permanently attached to the door shall contain system passwords and inspection logs. The enclosure shall also provide two (2) key ring holders for system keys and a location for a standard size business card with service contact information. The cabinet will have, permanently and securely mounted inside, a digital flash memory device with a minimum of 4 GB of storage capacity and a standard USB B connector for uploading and downloading electronic versions of record documents and system programming information.

B. The cabinet shall be red in color with an identification label reading "FIRE ALARM DOCUMENTS". Refer to Identification Section 26 05 53. The cabinet shall be lockable.

C. The final version of the system database program shall be stored within the cabinet.

1.13 WARRANTY

A. Provide one (1) year warranty on all materials and labor from Date of Substantial Completion.

B. Warranty requirements shall include furnishing and installing all software upgrades issued by the manufacturer during the one (1) year warranty period.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Johnson Controls - Simplex
B. Notifier by Honeywell
C. Edwards - EST
D. Siemens Fire Safety
E. Gamewell - FCI

2.2 [FAP-#]: FIRE ALARM CONTROL PANEL (FAP)

A. Control Panel: Modular, power-limited electronic design. Provide surface wall-mounted enclosure as shown on plans. Enclosure shall be minimum 0.060 steel with provisions for electrical conduit connections into the sides and top. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators.

B. Each Signaling Line Circuit (SLC loop) shall not be loaded over 80% of the maximum device capacity. For example, in the minimum system capacity column listed below, if the fire alarm manufacturer's system capacity of analog sensors per loop is 99 devices, then no more than 79 devices shall be wired on that loop. The minimum system capacity shall be as follows:

Minimum Total Addressable Points:	250
Minimum Total SLC loops (including board, ready for field connections):	2

C. Signal Line Circuit Board (SLC):

1. Each board shall communicate directly with each addressable analog sensor and binary input to determine normal, alarm, or trouble conditions. Analog signals would be used for automatic test and determination of maintenance requirements.

2. Each board shall contain its own microprocessor and shall be provided to monitor addressable inputs and to control addressable outputs (addressable relays). The board shall communicate and provide power to all devices on its loop over a single pair of wires, except where 4-wire devices require a separate power circuit.

3. Class A, Style 6: Circuits capable of transmitting an alarm signal during an open or a non-simultaneous single ground fault on a circuit conductor wiring system. Wiring of outgoing and return conductors shall be physically separated by a minimum of 50 feet or by a two-hour rated enclosure.

4. Class B, Style 4: Circuits NOT capable of transmitting an alarm beyond the location of the fault condition. Wiring of outgoing and return conductors is permitted to be run in the same conduit or cable.

5. SLC for addressable devices with less than 50 devices can be Class A or B, and more than 50 devices shall be Class A.

D. Notification Appliance Circuit (NAC) Board:

1. Each board shall contain its own microprocessor and shall be provided to control each notification appliance circuit. The board shall communicate and provide power to all devices on its loop.

2. Class B, Style Y: Circuits NOT capable of transmitting an alarm beyond the location of the fault condition. Wiring of outgoing and return conductors is permitted to be run in the same conduit or cable.

3. Class A, Style Z: Circuits capable of transmitting an alarm signal during an open or a non-simultaneous single ground fault on a circuit conductor. Wiring of outgoing and return conductors shall be physically separated by a minimum of 50 feet or by a two-hour rated enclosure.

E. Central Processing Unit:

1. The central processing unit (CPU) shall communicate with the monitor and control all other modules in the panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the CPU.

2. The CPU shall execute all control-by-event programs for specific action to be taken if a designated situation is detected in the system. A real-time system clock for time annotations on the display and printer shall be included.

3. All power for the unit shall be supervised and supplied by the FAP.

F. Display:

1. The board shall provide all controls and indicators used by the system operator and may also be used to program all control panel parameters.

2. The board shall provide an alphanumeric array for display of custom alphanumeric labels for all addressable points. It shall also provide indicators for AC Power, System Alarm, System Trouble, Display Trouble and Signal Silence.

3. Displayed descriptions of addressable points shall include actual room names/numbers selected by the Owner. This information shall be obtained prior to programming. Room names/numbers shown on floor plans shall not be used.

4. The board shall provide a touch key-pad with control capability to command all system functions and entry of any alphanumeric information. Twenty different passwords with four levels of security shall be supported to prevent unauthorized manual control or programming.

G. Memory: The CPU and display interface board shall be augmented by non-volatile field programmable memory. EPROM memory will also be allowed provided the memory is burned in with minimum expansion capability equal to the total system capacity of the panel. Memory shall not be lost upon primary and secondary power failure.

H. Serial Interface Board: The board shall provide interfaces to a printer, LCD display and other monitoring devices through RS-232 connections. The minimum operational distance between the board and the peripheral devices shall be 500 feet. Up to three (3) RS-232 outputs shall be supported.

I. Power Supply:

1. Input power shall be 120 VAC, 60 Hertz. Output power shall be as noted on the device specifications and drawings. Each component of the fire alarm system requiring 120 VAC input power shall be served from a dedicated branch circuit. Provide two #12 conductors and one #12 ground in 3/4" conduit to a dedicated 20A/1P circuit breaker with a red handle and a manufacturer's standard handle lock-on device. Identify/label breaker and branch circuit in accordance with NFPA requirements and Specification Section 26 05 53.

2. Adequate to supply 125% of all control panel and peripheral power needs as well as 125% of power required for all external audio-visual devices. The power supply may be increased as needed by adding additional modular expansion power supplies. Over-current protections shall be provided on all power outputs.

3. All power supplies shall be designed and installed to meet UL and NFPA requirements for power-limited operation on all external initiating and indicating circuits.

4. The power supply shall provide integral charger for use with internal batteries. Battery capacity shall be sufficient for operation of the entire system for 24 hours in a non-alarm state followed by alarm mode for 15 minutes, plus 25% spare capacity for future devices.

J. Surge Protection:

1. All fire alarm control panels, NAC panels, etc. shall be provided with a surge protection device (SPD). The SPD shall be UL listed to Standard 1449 Rev 3. The unit should be clearly labeled in accordance with Identification Section 26 05 53. The SPD shall have thermal fuses to protect against fire in short circuit conditions. The unit shall provide visual indication that the unit is protecting and functioning.

2. Any communications or signaling circuits associated with the fire alarm system, which leave or enter a facility, shall be provided with a surge protection device. The devices shall be as recommended by the fire alarm system manufacturer.

K. Digital Communicator:

1. Provide dual phone line interface capable of fire alarm notification to the local fire department, fire protection agency, or monitoring service. Communicator shall report in SIA and most major communication formats, with the capability of transmitting each device address point in a format compatible with the central station receiver.

2. Communicator shall be fully supervised and shall operate on loop start phase lines ahead of the building PBX system.

3. Communicator shall be FCC registered. Contractor shall provide two RJ31X jacks. Contractor to provide connection of communicators to Owner's telephone system.

4. Approvals: UL listed - UL 864/NFPA 72, FM approved.

5. The communicator shall be provided integral to the fire alarm panel as furnished by the fire alarm panel manufacturer. If the panel construction requires a separate unit, the unit shall be as manufactured by Silent Knight, Ademco, or fire alarm panel manufacturer approved equal.

L. IP-GSM Digital Cellular Fire Communicator:

1. Provide digital internet / cellular phone interface capable of fire alarm notification to the local fire department, fire protection agency, or monitoring service. Monitoring fees and initial connection charges are not part of this project.

2. Contractor to provide connection of communicator to Owner's Ethernet 10/100 Base network connection. Wiring shall be in 1" conduit.

3. Communicator shall convert fire alarm control panel phone outputs into Ethernet packets and transmit to GSM networks in area including 2G, 3G and 4G.

4. Communication shall include system status including individual addressable device status, power loss, low battery and earth fault, and 24-hour test signal.

2.3 SIGNALING LINE CIRCUIT DEVICES

A. **[FA-120]:** Smoke Detectors:

1. Analog Photoelectric Type Sensor: Shall use the photoelectric principle to measure smoke density and send data to the control panel representing the analog level of smoke density measured.

2. Each smoke detector shall connect directly to an SLC loop.

3. Each detector shall be mounted, where shown on the drawings, on a twist-lock base with all mounting hardware provided. Provide a two-piece head/base design.

4. Each detector shall have a manual switching means to set the internal identifying code (address) of that detector, which the control panel shall use to identify its address with the type of sensor connected.

5. Dual alarm and power indicators shall be provided that flash under normal conditions and remain continuous under alarm or trouble conditions. Remote indicator terminals shall be provided. Provide a remote LED indicator device if detector is not visible from a floor standing position.

6. A test means shall be provided to simulate an alarm condition.

7. Where operation is noted as required below 32ºF and/or above 120ºF, a conventional device shall be installed with a unique monitor module located in the nearest available location with maintained temperatures between 32ºF and 120ºF.

8. Audible sounder detector base for sleeping room applications:

a. The audible base shall sound an alarm in the local room in UL2017 operation and UL484 for general evacuation. The unit shall be programmable by the main control panel for the duration of operation.

b. The audible sounder base shall sound Temporal 3 (fire) or Temporal 4 (CO alarm) and be at 75 dB at 10 feet.

9. A subscript is used to identify the device with a specific sequence of operation as follows: E=Elevator Recall, S=Sleeping/Patient Room, D=HVAC Control, A=Atrium, SW=Stairwell, CR=Computer Room, SD=Smoke Dampers, DH=Door Hold Release, FD= Fire Door Release, MP=Medical Procedure Room.

B. **[FA-121]:** Projected Beam Type Detectors:

1. This device shall utilize photoelectric analog smoke sensor technology. Provide with transmitter and associated receiver. Microprocessor-based detector shall provide a minimum of eight sensitivity levels, temperature and dirt compensation, and automatic gain control. Sensor to contain beam alignment adjustments and receiver calibration.

2. Detector shall connect directly to an SLC loop or shall be provided with multiple monitor modules, as required, to connect to the SLC loop and for monitoring alarm and trouble output contacts. The detector shall be provided complete with all mounting hardware provided and installed where indicated on the drawings.

3. Dual alarm and power indicators shall be provided that flash under normal conditions and remain continuous under alarm or trouble conditions. Remote indicator terminals shall be provided.

4. Provide with remote indicator panel providing LED indications of alarm and trouble.

C. **[FA-122]:** Duct Smoke Detectors:

1. Duct-type smoke detectors shall use the same analog photoelectric sensor technology, with the same features specified for standard smoke detectors, except with additional features as specified below.

2. Provide sampling tubes and mounting hardware to match the duct to which it is attached. Where the detector housing is larger than the duct height, the Contractor shall fabricate a mounting bracket for the detector and attach according to the fire alarm manufacturer’s recommendations.

3. Provide a remote alarm LED indicator device (FA-240/241) if detector is not visible from a floor-standing position. If detector is located above a suspended ceiling, mount remote indicator in ceiling directly below detector with a white single-gang faceplate labeled: Duct Smoke Detector.

D. **[FA-123]:** In-Duct Smoke Detectors:

1. Analog Photoelectric Type Sensor: Shall use the photoelectric principle to measure smoke density and send data to the control panel representing the analog level of smoke density measured.

2. Low Flow Type: Listed for use in duct with 0-2000 feet per minute velocity.

3. Each smoke detector shall connect directly to an SLC loop.

4. Each detector shall be mounted, where shown on the drawings, on a twist-lock base with all mounting hardware provided to match the duct application. Provide a two-piece head/base design.

5. Each detector shall have a manual switching means to set the internal identifying code (address) of that detector, which the control panel shall use to identify its address with the type of sensor connected.

6. Provide a remote LED indicator device (FA-240/241), mounted in ceiling directly below detector with a single-gang faceplate labeled: Duct Smoke Detector.

E. Manual Pull Stations:

1. Manual stations shall match the description on the drawings (refer to the General Electrical Equipment Schedule). The stations shall be mounted where shown on the drawings and be provided with all necessary mounting hardware.

2. **[FA-130]:** Addressable, double action, reset key lock, semi-flush mount, red high abuse plastic or cast metal construction with white lettering.

3. **[FA-131]:** Hazardous location, addressable, double action, red cast metal construction with white lettering. Class I, Div 2 rated. Edwards XAL-53 or equal.

4. Manual stations shall connect directly to an SLC loop. Stations shall provide address setting means using rotary decimal or DIP switches.

5. Where operation is noted as required below 32ºF and/or above 120ºF, a conventional device shall be installed with a unique monitor module located in the nearest available location, with maintained temperatures between 32ºF and 120ºF.

F. Heat Detectors:

1. **[FA-140]:** Combination rate of rise and 135°F fixed temperature analog thermal type sensor. Factory programmed to alarm at 135ºF and at 15ºF per minute rate-of-rise. Sensor shall measure heat level and send data to the control panel representing the analog level of thermal measurement and rate-of-rise.

   a. A subscript is used to identify the device with a specific sequence of operation as follows: E=Elevator Shutdown.

2. **[FA-141]:** 200°F fixed temperature. Provide a remote addressable monitor module to interface with addressable system as shown on the plans.

3. **[FA-142]:** Explosion-proof. Combination rate of rise and 135°F fixed temperature. Non-current carrying metal enclosure. Hazardous classification: Class I, Group D. Provide a remote addressable monitor module to interface with addressable system.

4. Provide a two-piece head/base design, with a manual switching means to set the internal identifying code (address) of that detector, which the control panel shall use to identify its address with the type of sensor connected.

5. Heat detectors shall connect directly to SLC loops. Where fixed temperature or explosion proof detectors are used, one monitor module may be used to monitor all detectors in one room/area as shown on the drawings.

6. Detectors shall be mounted, where shown on the drawings, on a twist-lock base with all mounting hardware provided.

7. Provide a remote LED indicator device if detector is not visible from a floor-standing position.

8. Dual alarm and power indicators shall be provided that flash under normal conditions and remain continuous under alarm or trouble conditions. A connection for attachment of a remote indicator shall be provided.

9. A test means shall be provided to simulate an alarm condition.

10. Where operation is noted as required below 32°F and/or above 120°F, a conventional device shall be installed with a unique monitor module located in the nearest available location with maintained temperatures between 32°F and 120°F.

G. **[FA-151]:** Flame Detector:

1. Microprocessor based design. Ultraviolet and infrared type detector. Swivel mount. Provide with anti-contaminant air shields and a remote test switch located at the fire alarm control panel. Provide two addressable monitor modules for monitoring alarm and fault output contacts.

H. **[FA-160]:** Monitor Modules:

1. Monitor Module shall connect directly to an SLC loop and receive power from a separate 24 VDC circuit. It shall interface initiating devices with the control panel using Style D or Style B circuits. Contractor option: Use an interface module (2-wire operation) for Style B circuits connected to normally-open dry contacts, such as a flow switch.

2. The module shall be mounted in an enclosure located in an accessible service location as near as possible to the device(s) being monitored, or where shown on the drawings. All mounting hardware shall be provided.

3. The module shall supply the required power to operate the monitored device(s).

4. The module shall provide address setting means using rotary decimal or DIP switches.

I. **[FA-161]:** Addressable Relays:

1. Relay that represents an addressable control point used primarily for the control of auxiliary devices as indicated on the drawings. Contractor to provide additional slave relay(s), as required, rated for the electrical load being controlled (contractor to match voltage, amps, etc.).

2. Relay shall connect directly to an SLC loop and receive power from a separate 24 VDC circuit.

3. The relay shall be mounted in an enclosure located in an accessible service location as near as possible to the device(s) being controlled, unless otherwise shown on the drawings. All mounting hardware shall be provided.

4. The relay shall supply 24 VDC power to the device(s) being controlled, unless otherwise indicated on the drawings.

J. **[FA-XX]:** Isolation Module:

1. Provide fault isolation modules or isolator detector base capable of isolating and removing the fault from Class A or Class X addressable loop data circuits while allowing the remaining data loop to continue operation. Provide a minimum of two isolation modules or bases and between every 15 devices.

2.4 NOTIFICATION APPLIANCE DEVICES

A. Device Color:

1. Wall Mounted: Red housing with white lettering or pictogram.

2. Ceiling Mounted: Red housing with white lettering or pictogram.

3. WG subscript indicates wire guard is required.

B. Visual Alarm Devices:

1. **[FA-200]:** Wall mounted.

2. **[FA-201]:** Ceiling mounted.

3. High intensity (candela rating as scheduled on the drawings) xenon strobe or equivalent under a lens. Candela rating shall be visible from exterior of the device.

   a. Candela Ratings: V1=15, V3=30, V7=75, VH=110, VS=177.

4. The maximum pulse duration shall be 0.2 seconds with a maximum duty cycle of 40%. The flash rate shall be 1 Hz. Where more than two strobes are visible from any one location, the fire alarm visual devices shall be synchronized.

5. Device, housing, and backbox shall be UL listed for fire alarm/emergency applications.

C. Audio (Horn) Alarm Devices:

1. **[FA-210]**: Wall mounted.

2. **[FA-230]**: Ceiling mounted.

3. Sound Rating: 85 dB at 10 feet. Sound levels for alarm signals shall not exceed 120 dBA in the occupied area.

4. Device shall be capable of a high and low dB level setting. Unless noted otherwise, the device shall be set to the high setting at building completion.

5. Device, housing, and backbox shall be UL listed for fire alarm/emergency applications.

D. Combination Audio (Horn) and Visual Notification Device:

1. **[FA-211]**: Wall mounted.

2. **[FA-231]**: Ceiling mounted.

3. Combine horn and visual components into a single device. Refer to the corresponding paragraphs above for requirements of each component.

E. **[FA-203]:** Weatherproof Visual Notification Device:

1. High intensity strobe, square housing, 75 candela rating, suitable for wet locations. Provide with weatherproof back box.

2. Mounting: Semi-flush wall.

3. Conduit shall not be exposed.

F. **[FA-212]:** Weatherproof Audio/Visual Notification Device:

1. Electronic horn with high intensity strobe, square housing, 75 candela, suitable for wet locations. Provide with weatherproof back box.

2. Mounting: Semi-flush wall.

3. Conduit shall not be exposed.

G. **[FA-232]:** Industrial Methane LEL detector, explosion proof housing, IP66 rated. Provide all necessary Modules and devices to integrate detector with fire alarm panel.

1. Acceptable manufacturer: Honeywell Sensepoint XCD

H. **[FA-233]:** Mini-Horn Audio Notification Device:

1. Electronic horn.

2. Mounting: single-gang flush wall.

I. **[FA-234]:** Explosion Proof Audio Notification Device:

1. Heavy-duty, high decibel, vibrating horn

2. Red, corrosion resistant heat flowed epoxy finish

3. Hazardous location, Class I, Div 2, and outdoor rated

4. 24VDC, 90dB @ 10’

5. Edwards 888D-N5 or equal

6. Provide addressable relay for control of notification device in accessible location.

J. **[FA-235]:** Explosion Proof Visual Notification Device:

1. Hazardous location, Class I, Div 2, and outdoor rated
2. 24VDC, 220 mA LED visual signal light.
3. Red lens covered with impact-resistant glass globe
4. Bracket mounting.
5. Light shall flash at 65 fpm.
6. Edwards 107XBRBMR120A or equal.
7. Provide addressable relay for control of notification device in accessible location.

2.5 [NEP-#]: NAC EXTENDER PANELS (NEP)

A. As shown on the plans or as a Contractor's option if not shown, furnish and install NAC extender panels as necessary to provide remote power supply for notification appliance circuits (NAC). Contractor shall indicate quantity and locations of each NEP on the shop drawing submittals.

B. Each NEP shall be self-contained remote power supply with batteries, and battery charger mounted in a surface lockable cabinet. Battery capacity shall be sufficient for operation for 24 hours in a non-alarm state followed by alarm for 15 minutes, plus 25% spare capacity for future devices. Each NEP provides a minimum of up to 4 outputs, 2A continuous, or 6A full load total capacity.

C. Power for each NEP shall be from a local 120 VAC circuit. Provide two #12 conductors and one #12 ground in 1/2" conduit to each NEP from a dedicated 20A/1P circuit breaker with a red handle and a manufacturer's standard handle lock-on device. Coordinate panel and circuit number with Architect/Engineer prior to installation.

D. NAC extender panels may be installed only in locations coordinated with the Owner/Engineer.

E. Mounting: Surface.

2.6 ANNUNCIATION

A. **[FAA-#]:** Remote LCD Annunciators:

1. Auxiliary annunciators shall indicate alarm and trouble conditions visually and audibly as shown on the drawings. Provide local TROUBLE ACKNOWLEDGE, TEST, and ALARM SILENCE capability. Minimum 80-character display.
2. Communications and power to the annunciators shall be supervised. The annunciator shall receive power from the fire alarm control panel.
3. A single key switch shall enable all switches on the annunciator.

B. Facility Management Control System (FMCS) Interface:

1. Provide BACnet IP interface for fire alarm panel to communicate status with the FMCS. Provide list of points and descriptions to FMCS supplier.

    a. UL listed to Standard 864. Provide RJ45 connection and cable.

C. **[FA-241]**: Fire Alarm Remote Indicator:

1. Red LED type.
2. Mounts flush to a single gang box.

D. **[FA-242]**: Fire Alarm Remote Indicator and Test Switch:

1. Red LED type.
2. Key switch test selector.
3. Mounts flush to a single gang box.

2.7 CONNECTIONS TO AUXILIARY DEVICES PROVIDED BY OTHERS

A. **[FA-260]**: Flow Switch:

1. Connection to flow switch to monitor fire protection flow switch or discharge output contacts. Normally open dry contacts for fire alarm interface. Furnished and installed and MC; wired by EC.

B. **[FA-261]**: Monitor Switch:

1. Connection to monitor switch to monitor fire protection system supervisory switches or output contacts. Normally open dry contacts for fire alarm interface. Furnished and installed by MC; wired by EC.

C. **[FA-262]**: Post Indicator Valve:

1. Connection to post indicator valve for sprinkler system supervisory notification. Normally open dry contacts for fire alarm interface. Furnished and installed by MC; wired by EC. Provide surge protection device as recommended by the fire alarm system manufacturer on line entering/leaving the facility.

D. **[FA-263]**: Electronic Bell:

1. Electronic bell for sprinkler alarm, electro-mechanical type, 120 VAC. Furnished and installed by MC. Fire alarm control and power connections by EC.

2.8 WIRING

A. Fire alarm wiring/cabling shall be furnished and installed by the Contractor in accordance with the manufacturer’s recommendations and pursuant to National Fire Codes. Cabling shall be UL listed and labeled as complying with NFPA 70, Article 760 for power-limited fire alarm signal service.

B. Approved manufacturers of fire alarm cable:

1. Comtran Corp.
2. Helix/HiTemp Cables, Inc.

3. Rockbestos-Suprenant Cable Corp.
4. West Penn Wire/CDT.
5. Radix.

PART 3 - EXECUTION

3.1 SEQUENCES OF FIRE ALARM OPERATION

A. General:

1. Refer to the Fire Alarm Operation Matrix on the drawings for basic requirements and system operation.

2. All system output programs assigned via control-by-event equations to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated.

B. Panel/Annunciator Alarm, Trouble, Supervisory Indication:

1. Appropriate system Alarm, Trouble, or Supervisory LED shall flash at the control panel, transponder, and annunciator locations.

2. A local signal in the control panel shall sound.

3. The LCD display shall indicate all information associated with the condition, including the name of the item, type of device and its location within the protected premises.

4. History storage equipment shall log the information associated with the fire alarm control panel (FAP) condition, along with the time and date.

5. Transmit the appropriate signal (supervisory, trouble, alarm) to the central station via the digital communicator.

6. Transmit the appropriate signal (supervisory, trouble, alarm) to the building automation system.

C. Audible Alarms Sequence:

1. Audible alarms throughout the facility shall sound.

D. Visual Alarms Sequence:

1. Visual alarms throughout the facility shall flash.

E. Fire Protection Electric Sprinkler Bell Sequence:

1. The fire alarm shall utilize an addressable relay to energize the electric sprinkler bell upon activation of the flow switch.

F. Double Interlocked Preaction Sprinkler Activation Sequence:

1. The fire alarm system shall utilize an addressable relay to signal the double-interlock preaction sprinkler system to allow filling with water upon initiation of alarm in zone of sprinkler coverage.

2. Where there are multiple zones to the preaction system, a separate addressable relay shall be provided for each zone and the system shall be programmed to signal only the zone that is in the area of the fire. Coordinate with the fire protection system installer.

3. The fire alarm system shall utilize addressable monitor modules to monitor the control panel supervisory and trouble conditions.

G. Smoke Damper Control Sequence:

1. All smoke and fire/smoke dampers shall be closed throughout thefacility.

H. AHU Shutdown Sequence:

1. All AHUs shall be shutdown simultaneously throughout the facility.

3.2 INSTALLATION

A. Install system in accordance with manufacturer's instructions and referenced codes.

B. Fire Alarm Control Panel:

1. Install the control panel where shown on the drawings.

2. All expansion compartments, if required, shall be located at the control panel.

C. Devices:

1. General:

a. All ceiling-mounted devices shall be located where shown on the reflected ceiling and floor plans. If not shown on the reflected ceiling or reflected floor drawings, the devices shall be installed in the relative locations shown on the floor drawings in a neat and uniform pattern.

b. All devices shall be coordinated with luminaires, diffusers, sprinkler heads, piping and other obstructions to maintain a neat and operable installation. Mounting locations and spacing shall not exceed the requirements of NFPA 72.

c. Where the devices are to be installed in a grid type ceiling system, the detectors shall be centered in the ceiling tile.

d. The location of all fire alarm devices shall be coordinated with other devices mounted in the proximity. Where a conflict arises with other items or with architectural elements that will not allow the device to be mounted at the location or height shown, the Contractor shall adjust location of device so that new location meets all requirements in NFPA 72 and all applicable building codes.

2. Per the requirements of NFPA, detector heads shall not be installed until after the final construction cleaning unless required by the local Authority Having Jurisdiction (AHJ). If detector heads must be installed prior to final cleaning (for partial occupancy, to monitor finished areas or as otherwise required by the AHJ), they shall not be installed until after the fire alarm panel is installed, with wires terminated, ready for operation. Any detector head installed prior to the final construction cleaning shall be removed and cleaned prior to closeout.

3. Protection of Fire Alarm System:

   a. A smoke detector shall be installed within the vicinity of the main fire alarm panel and every NAC extender panel per NFPA 72. A heat detector may be substituted when a smoke detector is not appropriate for the environment of installation.

4. Duct-type Analog Smoke Detectors:

   a. Duct-type analog smoke detectors shall be installed on the duct where shown on the drawings and details. The sampling tubes shall be installed in the respective duct at the approximate location where shown on the electrical drawings to meet the operation requirements of the system.

   b. All detectors shall be accessible.

   c. Duct-type detectors shall be installed according to the manufacturer's instructions.

5. In-Duct Analog Smoke Detectors:

   a. In-duct analog smoke detectors shall be installed in the duct where shown on the drawings and details. The devices shall be installed in the respective duct at the approximate location where shown on the electrical drawings to meet the operation requirements of the system.

   b. All detectors shall be accessible.

6. Manual Pull Stations:

   a. Stations shall be located where shown and at the height noted on the drawings.

7. Addressable Relays and Monitor Modules:

   a. Modules shall be located as near to the respective monitor or control devices as possible, unless otherwise indicated on the drawings.

b. All modules shall be mounted in or on a junction box in an accessible location.

c. Where not visible from a floor standing position, a remote indicator shall be installed to allow inspection of the device status from a local floor standing location.

8. Notification Appliance Devices:

a. Devices shall be located where shown on the drawings.

b. Wall-mounted audio, visual and audio/visual alarm devices shall be mounted as denoted on the drawings.

D. Annunciators:

1. Remote Annunciators: The annunciators shall be located where shown on the drawings and approved by the fire marshal.

E. Wiring:

1. Fire alarm wiring/cabling shall be provided by the Contractor in accordance with the manufacturer's recommendations and pursuant to National Fire Codes.

2. Wiring shall be installed in conduit. Refer to Identification Section 26 05 13 for color and identification requirements.

3. All junction boxes with SLC and NAC circuits shall be identified on cover.

4. Fire Alarm Power Branch Circuits: Building wiring as specified in Section 26 05 13.

5. Notification Appliance Circuits shall provide the features listed below. These requirements may require separate circuits for visual and audible devices.

a. Fire alarm temporal audible notification for all audio appliances.

b. Synchronization of all visual devices where two or more devices are visible from the same location.

c. Ability to silence audible alarm while maintaining visual device operation.

6. Notification Appliance Circuits shall not span floors.

7. Signal line circuits connecting devices shall not span floors.

8. No wiring other than that directly associated with fire alarm detection, alarm or auxiliary fire protection functions shall be in fire alarm conduits. Wiring splices shall be avoided to the extent possible, and if needed, they shall be made only in junction boxes, and enclosed by plastic wire nut type connectors. Transposing or changing color coding of wires shall not be permitted. All conductors in conduit containing more than one wire shall be labeled on each end, in all junction boxes, and at each device with "E-Z Markers" or equivalent. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its

terminal. Cabinet terminals shall be numbered and coded, and no unterminated conductors are permitted in cabinets or control panels. All controls, function switches, etc. shall be clearly labeled on all equipment panels.

F. Fire Alarm Cabling Color Code: Provide circuit conductors with insulation color coding as follows, or using colored tape at each conductor termination and in each junction box.

1. Power branch circuit conductors: In accordance with Section 26 05 53.
2. Signaling line circuit: Overall red jacket with black and red conductors.
3. DC power supply circuit: Overall red jacket with violet and brown conductors.
4. Notification appliance circuit: Overall red jacket with blue and white conductors.
5. Door release circuit: Gray conductors.
6. Central station trip circuit: Orange conductors.
7. Central station fire alarm loop: Black and white conductors.

G. Devices surface mounted in finished areas shall be mounted on surface backboxes furnished by fire alarm equipment supplier. Backboxes shall be painted to match device, and shall not have visible knockouts.

H. Make conduit and wiring connections to door release devices, sprinkler flow and pressure switches, sprinkler valve monitor switches, fire suppression system control panels, duct analog smoke detectors and all other system devices shown or noted on the Contract Documents or required in the manufacturer's product data and shop drawings.

3.3 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 26 05 00.

B. Test in accordance with NFPA 72, Chapter 14 and local fire department requirements. Submit documentation with O & M manuals in accordance with Section 14.6 of the Code.

C. Contractor shall test and adjust the fire alarm system as follows:

1. Speaker taps shall be adjusted to the lowest tap setting which achieves a sound level higher than or equal to the greatest of the following:

    a. 70dBA.

    b. 15 dBA above ambient levels as indicated in NFPA 72 Table A.18.4.3.

    c. 15 dBA above measured ambient. 5 dBA above the maximum measured sound level with duration of more than 60 seconds.

    d. As specified on the drawings.

2. Sound level measurement procedure shall meet the following requirements:

    a. All measurements shall use the 'A' weighted, dBA, sound measurement scale.

    b. All measurements shall be taken after furnishings, wall coverings and floor coverings are in place.

c. All measurements shall be taken after fixed equipment (HVAC units, etc.) producing ambient noise is installed and is in operation.

d. All sound level measurements shall be taken at a height of 5' above the finished floor level.

e. Measurements shall be taken in every unique room. If there are multiple rooms, which have the identical dimensions and function, 10%, or a minimum of 2 rooms shall be tested. The results from the rooms tested shall be averaged and the remaining rooms may be adjusted per the average.

f. Measurements shall be taken on a 20' x 20' grid and the results for all points taken shall be averaged. If the room is smaller than 20' x 20' a minimum of two measurements are required.

g. Measurements shall be taken halfway between speakers or halfway between a speaker and the wall. No measurements shall be taken at the extreme edges of the room, nor directly under speakers.

3.4 MANUFACTURER'S FIELD SERVICES

A. Provide manufacturer's field services under provisions of Section 26 05 00.

B. Include services of certified technician to supervise installation, adjustments, final connections, and system testing.

C. Note that room numbers depicted on the drawings will not necessarily reflect the actual room (signage) numbers that the Owner selects. The Contractor and fire alarm manufacturer shall coordinate the actual room numbers as the Owner directs to identify each device. This list shall be a part of the floor plan record drawing to be turned in at the project closeout.

3.5 SYSTEM TRAINING

A. System training shall be performed under provisions of Section 26 05 00.

B. Minimum on-site training times shall be:

1. System Operators: One (1) day.

END OF SECTION

SECTION 31 00 00

EARTHWORK

PART 1 - GENERAL

1.1 Section Includes

A. Excavating, hauling, grading, sorting, stockpiling, placing, conditioning, and compacting soil and rock materials including finish-grading necessary and incidental to accommodate lines, grades, thicknesses, and typical sections shown on the Drawings or specified, including borrow areas.

B. Construction & Maintenance of haul roads to and from construction borrow and stockpile areas.

C. Finish grading of stockpiles and borrow areas.

D. Restoration of disturbed surfaces to specified lines, grades, and contours.

1.2 References

A. Refer to Geotechnical Exploration Report (CGC, Inc: Project Number C1789, December 7, 2017)

B. Wisconsin Department of Transportation (WISDOT) standard specification for construction 2017, or latest edition.

1.3 Definitions

A. Relative compaction – As defined in the Soils Report. Refers to the in-place dry density of soil expressed as a percentage of maximum dry density of the same soil, as determined by ASTM Test Method 1557.

B. Special Fill, as defined in the Geotechnical Exploration Report for use in stabilizing subgrades, backfilling undercut excavations or filling behind retaining walls.

C. General Fill: Consistent, on-site soil materials free from organic matter, or any other non-soil material which by decomposition might cause settlement. Fill containing rock, boulders or concrete pieces should include sufficient finer material to fill voids among the larger fragments. Materials shall be placed, spread and leveled in layers no more than 10 inches thick before compaction.

1.4 Submittals

A. Submit documentation that materials meet the Specification and Drawing requirements.

B. Submit grain size analysis for proposed pipe bedding material and Geotechnical Approved Subgrade.

C. Submit samples for proposed pipe bedding material and Geotechnical Approved Subgrade.

D. Submit documentation for proposed Rip-Rap materials.

PART 2 - PRODUCTS

2.1 Fill Materials

A. Unclassified Fill (Fill not classified below): Use existing excavated soils from on-site or borrow area. To be supplied by OWNER.

B. Geotechnical Engineering Approved Subgrade.

C. General Fill: on site excavated or borrow material meeting the specifications in Section 31 23 26, free from organic matter.

2.2 Special Fill Materials

A. Gradation of Special Fill Materials:

Table 1
Gradation of Special Fill Materials

Material	WisDOT Section 311	WisDOT Section 312	WisDOT Section 305			WisDOT Section 209		WisDOT Section 210
	Breaker Run	Select Crushed Material	3-in. Dense Graded Base	1 1/4-in. Dense Graded Base	3/4-in. Dense Graded Base	Grade 1 Granular Backfill	Grade 2 Granular Backfill	Structure Backfill
Sieve Size	Percent Passing by Weight							
6 in.	100							
5 in.		90-100						
3 in.			90-100					100
1 1/2 in.		20-50	60-85					
1 1/4 in.				95-100				
1 in.					100			
3/4 in.			40-65	70-93	95-100			
3/8 in.				42-80	50-90			
No. 4			15-40	25-63	35-70	100 (2)	100 (2)	25-100
No. 10		0-10	10-30	16-48	15-55			
No. 40			5-20	8-28	10-35	75 (2)		
No. 100						15 (2)	30 (2)	
No. 200			2-12	2-12	5-15	8 (2)	15 (2)	15 (2)

Notes:
1. Reference: Wisconsin Department of Transportation *Standard Specifications for Highway and Structure Construction.*
2. Percentage applies to the material passing the No. 4 sieve, not the entire sample.
3. Per WisDOT specifications, both breaker run and select crushed material can include concrete that is 'substantially free of steel, building materials and other deleterious material'.

2.3 Rip Rap

A. Rip Rap comply with WisDOT standard specifications for riprap and meet the sizes shown on the plans.

B. Rip Rap in channels shall consist of a clean, angular stone resistant to weathering with a D_{50} of 6-inches. 50% of the stone by weight, should be larger than the D_{50}. The diameter of the largest stone should not exceed 1.5 times the D_{50} size.

C. Rock outlet Protection stone shall consist of the following:

Percent Passing by Weight	Diameter (inches)
100	2 x D_{50}

60-85	1.5 x D_{50}
25-50	D_{50}
5 -20	0.5 x D_{50}
0-5	0.2 x D_{50}

Refer to Plans for D_{50} sizes.

2.4 Stone Tracking Pad

A. Aggregate material used shall consist of a 3 -6-inch washed stone. All material to be retained on a 3-inch sieve.

2.5 Stone Check Dams

A. Materials consist of a well graded angular stone with a D_{50} of 3 inches or greater with no more than 5% passing the #4 sieve, free of fines and sands. The one foot layer shall consist of a 1-inch (#2) washed stone over the 3 to 6-inch clear stone. Angular stone meeting the gradation for WisDOT specification 312 select crushed or local equivalent.

2.6 Storm Basin Riser Pipe Stone

A. The one foot layer shall consist of a 1-inch (#2) washed stone. Angular stone meeting the gradation for WisDOT specification section 312 select crushed or local equivalent.

2.7 Infiltration Trench

A. Top layer to consist of clean sand meeting one of the following gradation requirements:

i. United States Department of Agriculture (USDA) Course Sand (0.02-0.04 inches),

ii. ASTM C33 (Aggregate Concrete Sand or

iii. WISDOT Section 501.2.5.3.4 (Final Aggregate Concrete Sand) 2005 edition, or equivalent.

The preferred sand component consists mostly SiO_2, but sand consisting of dolomite or calcium carbonate may also be used. Manufactured sand or stone dust is not allowed. The sand shall be washed and drained to remove clay and silt particles prior to mixing.

B. Bottom layer gravel shall meet the coarse aggregate #2 and other specifications of Wisconsin Standards and Specifications for Highway and Structure Construction, Section 501.2.5, 2003 edition, or equivalent as approved by the administering authority. Gravel shall be double washed.

2.8 Granular Materials

A. Granular Fill: Bedding Material is for pipes outside of the limits of waste.

i. Have primarily sand size particles or sand-sized particles mixed with gravel, crushed gravel, or crushed stone. Do not use materials classified under WISDOT section 301.2.4.3 as crushed concrete, reclaimed asphalt, reprocessed material, and blended material.

ii. Have a maximum particle diameter of 1-½ inches.

iii. Have a moisture content suitable for satisfactory consolidation with the compaction tool used.

iv. Have a liquid limit less than or equal to 25 and a plasticity index less than or equal to 6.

2.9 Topsoil

A. Topsoil shall meet the specifications in Section 31 23 29. To be provided by OWNER.

PART 3 - EXECUTION

3.1 Excavation Preparation

A. Remove ice and snow before excavation.

B. Identify required construction survey control lines and datum.

C. Mark all trees identified for removal.

D. Notify area utility companies prior to commencing work in accordance with state and local regulations.

3.2 Excavation

A. Remove trees, stumps, root systems, rocks and objects larger than 6 inches in size to depth of 1 foot below required subgrade elevations, and as required to allow for proper, efficient construction. Apply appropriate herbicide to remaining stump material to inhibit growth. Refer to Section 02 01 00 for disposal of materials that will not be reused.

B. Strip topsoil from project areas, including stockpile areas prior to stockpiling, to whatever depths encountered; prevent intermingling with underlying subsoil or other objectionable material. Remove heavy growths of grass from areas before stripping topsoil. Stockpile / re-use as shown. Clear undergrowth and deadwood, without disturbing subsoil.

C. Excavate soils as required to accommodate new site grades as shown on the Drawings and specified herein. Grade perimeter of excavation, to prevent surface water drainage into excavation and ponding of water.

D. Identify materials within the indicated excavation areas which will meet the required specifications for Topsoil. Excavate and place Overburden soils encountered in stockpile area if not used for Topsoil fill. Separate from stockpile for the Topsoil material within the construction limits. Stockpile areas to be approved by OWNER. Excavation of Unclassified Fill soils shall be placed in stockpile area as directed by Owner.

E. Stockpile excavated material in areas designated. Keep general/structural fill in the stockpiles separate from topsoil, and other unclassified fill. Do not inter-mingle topsoil, and General / Structural Fill. Grade stockpile areas to provide positive drainage.

F. Excavate soils to the minimum depth required for execution of work and as required to accommodate new site grades as shown on the Drawings and specified herein. Provide sufficient room for aggregate base compacted to at least 95 percent relative compaction. Grade perimeter of excavation to prevent surface water drainage into excavation and ponding of water.

G. Notify Soils Engineer of unexpected subsurface conditions, and discontinue affected work in area until notified by Engineer to resume work.

3.3 Preparation for filling, backfilling, and compacting

A. Remove ice and snow before placing fill. Do not place fill on frozen subgrade.

B. Strip areas of topsoil prior to placing fill. Stockpile topsoil in area designated on-site.

C. Proof roll subgrade before placing fill using loaded scrapers, haul truck or compaction equipment. Cut out or rework soft areas of unsuitable subgrade. Undercuts will be performed in accordance with Section 31 23 16.

D. Scarify all soils prior to installation of Engineered Fill. If surface soil has dried, scarify to at least 2 inch depth and moisture condition.

3.4 Placement and Compaction

A. Begin engineered fill placement only when underlying subgrade has been accepted by the Owner.

B. Prior to placement of engineered fill verify that no substantial thickness of loose or uncompacted soil is present in the fill area.

C. Blend slopes with existing landscape features, at the intersection of cuts and fills; provide gradual slope between new and existing construction.

D. Maintain positive drainage.

E. Maintain and/or adjust moisture content to achieve specified compaction. Use compactors well suited for the soil type being compacted.

F. Fill and foundation excavations shall be observed and approved by the Soils Engineer prior to placing concrete.

G. All Engineered fill and subgrade material proposed for use shall be approved by the Soils Engineer prior to placement.

H. Place and spread Engineered Fill in lift thicknesses as required to obtain the specified levels of compaction. Engineered fill should not be placed in lifts no more than 10 inches thick.

I. Engineered Fill and Geotechnical Approved Subgrade shall be compacted in accordance with the soils report and ASTM D-1557. Flooding not permitted. Refer to table below.

Compaction Guidelines

Area	Percent Compaction (1) Clay/Silt	Percent Compaction (1) Sand/Gravel
Within 10 ft of building lines		
Footing bearing soils	93 - 95	95
Under floors, steps and walks		
- Lightly loaded floor slab	90	90
- Heavily loaded floor slab and thicker fill zones	92	95
Beyond 10 ft of building lines		
Under walks and pavements		
- Less than 2 ft below subgrade	92	95
- Greater than 2 ft below subgrade	90	90
Landscaping	85	90

Notes:

1. Based on Modified Proctor Dry Density (ASTM D 1557)

J. Compact materials immediately after placement.

K. Slabs: place and compact Geotechnical Engineering Approved Subgrade over scarified subgrade soils below all slabs in no less than 3 inch compacted lifts. Refer to Section 31 23 00 for additional information.

L. Paved areas: place and compact 4 –inch thick, 1-1/4 in. Dense Grade Base (DGB) over approved, bottom part 6-inch thick, 3-inch DGB, under a moisture-conditioned and scarified Engineered fill below parking lot areas in no less than 6 inch compacted lifts.

3.5 Fill Stockpiles / Borrow Areas

A. Grade stockpiles to provide positive drainage. Maximum slopes shall be 3:1 unless approved by Owner. Seal by tracking with dozer or other means to minimize erosion and limit surface water infiltration.

B. Areas around stockpiles shall be graded to drain. Haul roads constructed to and from stockpile / borrow areas shall not restrict surface water drainage patterns. Haul road locations to be submitted with Bid and deviations from that submitted must be approved by Owner in advance of constructing.

C. Borrow areas shall be graded to drain upon completion, with intent to minimize surface water pumping required by Owner thereafter. Work with Owner to agree on grading plans.

3.6 Field Quality Control

A. Representative samples of soils shall be submitted to the Field Engineer and tested for optimum moisture-maximum density determination (ASTM D1557) prior to the start of fill placement. Sample size should be approximately 50 pounds.

B. Field density tests to determine the level of compaction being achieved in the placed soil. The test shall generally be conducted on each lift at the beginning of fill placement and at a frequency mutually agreed upon by the project team for the remainder of the project.

* * * END OF SECTION * * *

SECTION 31 23 00

FOUNDATION EXCAVATING AND BACKFILLING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General and Supplementary Conditions of the Construction Contract and Division 1 - General Requirements apply to the work specified in this section.

B. This section shall include, but is not limited to the following foundation, excavating and backfilling within five feet of the building perimeter.

1. Removal of all unacceptable soil.

2. Furnish and install acceptable fill as specified herein and on the drawings.

3. Prepare subgrade for footings and slab on grade.

C. The following items are not a part of this specification:

1. Utility trenching and related backfilling outside the building footprint.

2. Subgrade for exterior walks and paving.

D. Structural notes indicated on the drawings regarding foundation excavating and backfilling should be considered part of this specification.

1.2 QUALITY ASSURANCE

A. Codes and Standards: Comply with the provisions of the following codes, specifications and standards, except where more stringent requirements are shown or specified.

1. ASTM C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

2. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbs/ft^3)

3. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using the Modified Effort. (56,000 ft-lbs/ft^3)

4. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).

5. ASTM D2940 - Standard Specification for Graded Aggregate Material for Bases and Sub-bases for Highways or Airports.

6. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

7. ASTM D4254 - Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

8. ASTM D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

B. Comply with all applicable local, state and federal codes.

1.3 SUBMITTALS

A. Material Test Reports: Provide the Owner and Engineer with the on-site material test reports from the Inspection Agency indicating the interpreting test results for compliance with this specification.

1.4 TESTING AND INSPECTION

A. Inspection and Testing:

1. The Owner shall employ an Inspection Agency to perform the duties and responsibilities specified below.

2. Refer to civil, mechanical, and electrical specifications for testing and inspection requirements of non-structural components.

3. Duties of the Inspection Agency:

a. Perform all testing and inspection required per the Testing and Inspection Schedule indicated below.

b. Furnish inspection reports to the building official, the Owner, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work.

c. Submit a final signed report stating whether the work requiring Inspection was, to the best of the Inspection Agency's knowledge in conformance with the approved plans and specifications.

4. Structural Component Testing and Inspection Schedule for Section 31 23 00 is as follows:

Foundation Preparation	Continuous	Periodic
Verify materials below shallow footings are adequate to achieve the design bearing capacity.		X
Verify excavations are extended to proper depth and have reached proper material.		X
Perform classification and testing of compacted fill materials.		X
Verify use of proper materials, densities, and lift thicknesses during placement and compaction of compacted fill.	X	
Prior to placement of compacted fill, observe subgrade and verify that the site has been properly prepared.		X

B. Minimum testing frequency and locations:

1. Laboratory Testing:

a. Granular fill: One representative gradation test for each type of material.

b. Cohesive soils: One representative moisture density test for each type of material used.

c. Non-cohesive soils: One representative moisture density test for each type of material used.

2. Field Testing:

a. The Inspector shall determine the location of testing.

b. Testing of final utility trench backfill shall begin at a depth of 2 feet above the top of the pipe.

c. In-place field density test and moisture content tests shall be performed as follows:

1) Fills not within the influence of building foundations and slab on grade: Per civil specifications.

2) Fills within the influence of building foundations and slab on grade, the following criteria shall apply: One test for each 10 inch vertical lift of compacted fill placed per 2,500 square feet of fill area (minimum of two tests per lift per structure for areas smaller than 5,000 square feet).

d. Additional testing may be required by the Inspector if noncompliance or a change in conditions occurs.

e. If a test fails, the Contractor shall rework the material, recompact and retest as necessary until specific compaction is achieved in all areas of the trench. All costs associated with this work, including retesting, shall be the responsibility of the Contractor.

1.5 PROTECTION

A. Contractor shall provide for design, permits and installation of all cribbing, bracing, shoring and other methods required to safely retain earth banks and excavations.

B. Notify the Engineer of unexpected subsurface conditions and discontinue work in affected areas until notification to resume.

C. Protect benchmarks, existing structures, fences, sidewalks, paving, curbing, etc., from excavation equipment and vehicular traffic.

D. Maintain and protect above and below grade utilities that are to remain.

E. Provide temporary heating or protective insulating materials to protect subgrades and foundations soils against freezing temperatures or frost during cold weather conditions.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide borrow soil materials when sufficient acceptable soil materials are not available from excavations.

B. Acceptable soils shall comply with the following:

1. Meet ASTM D2487 soil classification groups GW, GP, GM, SW, SP, SM or a combination of these group symbols;

2. Be free of rock or gravel larger than 3 inches in any dimension;

3. Be free of debris, waste, frozen materials, vegetation and other deleterious materials;

4. Have a liquid limit less than 45 and a plasticity index less than 20.

5. Be approved by the Inspection Agency.

C. Unacceptable soils shall be defined as following:

1. ASTM D2487 soil classification groups GC, SC, ML, MH, CL, CH, OL, OH, PT or a combination of these group symbols.

2. Unacceptable soils also to include acceptable soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Free-Draining Granular Fill: Free-draining granular fill shall comply with the following:

1. Be a naturally or artificially graded mixture of natural or crushed gravel, crushed stone.

2. Be clean and free of fines.

3. Comply with ASTM D2940.

4. Be uniformly graded as follows:

COARSE AGGREGATE GRADATIONS						
SIEVE SIZE - PERCENT PASSING						
Grade No.	1-1/2"	1"	3/4"	1/2"	3/8"	No. 4
CA7	100	95 ± 5	-	45 ± 15	-	5 max

5. Be approved by the Inspection Agency.

E. Engineered Fill and Utility Base Course shall comply with the following:

1. Be a naturally or artificially graded mixture of natural or crushed gravel, crushed stone, natural or crushed sand;

2. Comply with ASTM D2940;

3. Be uniformly graded as follows:

COARSE AGGREGATE GRADATIONS						
SIEVE SIZE - PERCENT PASSING						
Grade No.	1-1/2"	1"	1/2”	No. 4	No. 16	No. 200
CA6	100 to 90	95 ± 5	75 ± 15	43 ± 13	25 ± 15	8 ± 4

4. Be approved by the Inspection Agency.

F. Dense Graded Base:

1. Be a naturally or artificially graded mixture of natural or crushed gravel, crushed stone, natural or crushed sand;

2. Comply with ASTM D2940;

3. Be uniformly graded as follows:

COARSE AGGREGATE GRADATIONS							
SIEVE SIZE - PERCENT PASSING							
Grade No.	1 1/4"	3/4"	3/8”	No. 4	No. 10	No. 40	No. 200
CA6	100 to 95	70-93	42-80	25-63	16-48	8-28	2-12

4. Be approved by the Inspection Agency.

G. Material Applications: Provide and install material meeting with the above requirements as follows:

1. General fill: Acceptable soils.

2. Backfill at over-excavated areas beneath footings: Engineered fill.

3. Sub-grade layer beneath slabs-on-grade: Refer to Drawings.

PART 3 - EXECUTION

3.1 PREPARATION

A. Identify and verify required lines, levels, contours and benchmark elevations for the work are as indicated.

B. Protect plant life, lawns, other features and vegetation to remain as a portion of the final landscaping.

C. Identify known underground utility locations with stakes and flags.

D. Site preparation summary is based on Section 1 of Geotechnical report by CGC, Inc. dated December 7, 2017. Refer to report for full summary.

1. Strip top soil at least 10 feet beyond building foot prints. Top soil ranged from 4 to 30 inches in thickness. Remove organic items (trees and tree roots).

2. Compact the exposed soils and proof-roll with a heavy piece of rubber-tire construction equipment to check for soft or yielding areas. If soft or yield areas are encountered, correct per soils report.

3. Fill with granular soils within the building envelopes. On-site soils should not be used.

4. With the widespread presence of slightly compressible cohesive and fine-grained soils under the site, a time delay of 4 to 8 weeks is required between fill placement and beginning footing construction. Use settlement platforms or monitoring plates as described in geotechnical report.

5. The normal construction sequence can begin after the settlement data indicates that settlement as largely ceased.

6. If fill placement occurs at least 3 months prior to building construction, settlement monitoring will not be required.

3.2 EXCAVATION

A. All excavations shall be safely and properly backfilled.

B. All abandoned footings, utilities and other structures that interfere with new construction shall be removed.

C. All unacceptable material and organic material shall be removed from below all proposed slabs-on-grade and the exposed natural soil shall be proof rolled and the compaction verified by the soils testing firm prior to placing fill. Proof-roll with a loaded tandem dump truck, loaded ready-mix truck, roller, or equivalent weight vehicle. Materials exhibiting weakness, such as those exhibiting rutting or pumping, shall be removed and replaced with acceptable compacted fill material.

D. Do not excavate within the 45-degree bearing splay of any adjacent foundations.

E. Outside 45-degree bearing splay of foundations, correct areas over excavated with aggregate at no additional cost to the Owner.

F. Within the 45-degree bearing splay of foundations, correct areas over excavated with 2000 psi concrete fill at no additional cost to the Owner. Notify the Engineer prior to performing such work.

G. Hand trim final excavation to remove all loose material.

H. Contractor shall form all dams and perform other work necessary for keeping the excavation clear of water during the progress of the work and, at his own expense, shall pump or otherwise remove all surface and perched water which accumulates in the excavations. Perched water that cannot be de-watered in 48 hours of continuous pumping at a minimum rate of 60 gpm in dry weather shall be considered ground water.

I. Stockpile excavated material in the area designated and remove excess material not being used, from the site.

3.3 BACKFILLING

A. Support pipe and conduit during placement and compaction of bedding fill.

B. Systematically backfill to allow necessary time for natural settlement. Do not backfill over porous, wet, spongy or frozen subgrade surfaces.

C. Backfill areas to contours and elevations with unfrozen materials.

D. Unless noted otherwise on the Drawings, make grade changes gradual.

E. Unless noted otherwise on the Drawings, slope grade away from the building a minimum of 2 inches in 10 feet.

F. Contractor shall procure the approval of the subgrade from the Inspection Agency prior to the start of any filling or bedding operations.

G. Do not begin any backfill operations against any concrete walls until the concrete has achieved its specified strength.

H. Place and mechanically compact granular fill in continuous layers not to exceed 10 inches compacted depth when using large equipment mounted compactors and 5 inches when using hand compactors.

I. Employ a placement method that does not disturb or damage adjacent utilities, vapor barriers, foundation perimeter drainage and foundation waterproofing.

J. All surplus fill materials are to be removed from the site.

K. Fill material stockpiles shall be free of unacceptable soil materials.

L. After work is complete, remove all excess stockpile material and repair stockpile area to its original condition.

3.4 COMPACTION

A. Compact all fill that will support building footings or floor slabs to 95 percent of the maximum dry density in accordance with ASTM D1557. For relative cohesionless fill materials, where the percent passing the #200 sieve is less than 10 and the moisture density curve indicates only slight sensitivity to changing moisture content, compaction requirements should be changed to 75 percent relative density in accordance with ASTM D4253 and ASTM D4254.

B. Compact all fills that support paving and landscape per civil specifications.

3.5 FOUNDATIONS

A. Each footing excavation should be cleared of all obstructions and other organic or deleterious materials.

B. Localized areas of unstable or unacceptable material may be discovered during the stripping and excavation operation and may require over-excavation and backfilling. The Inspection Agency shall be present during the proof rolling to evaluate any localized areas and make recommendations regarding over-excavation, backfilling and recompaction of these areas. Fill placement and compaction shall be inspected and tested by the Inspection Agency.

C. Footing elevations shown on the Drawings designate a minimum depth of footing where a safe soil bearing pressure is expected. Footings, piers and/or walls shall be lowered or extended as required to reach soil meeting the design bearing pressure. This work shall be performed under direct supervision of the Inspection Agency.

D. All footing excavations shall be recompacted by hand-operated, vibratory compaction equipment.

E. All excavation and recompacted surfaces shall be inspected and tested to a depth of 2.0 feet below the excavated elevation by the Inspection Agency. Additional field density tests should be performed for each one foot of fill material placed. Any areas not in compliance with the compaction requirements should be corrected and re-tested prior to placement of fill material.

F. For foundation areas where over excavation is performed, place and mechanically compact Engineered fill material in continuous layers not to exceed 10 inches compacted depth.

3.6 SLAB-ON-GRADE

A. All disturbed areas after the clearing and stripping operation should be proof-rolled and recompacted with a heavy vibratory drum roller (approved by the Inspection Agency) in the static mode. The compactor should make a minimum of 10 passes, with a minimum of one foot overlap of each pass. The compactor speed should be less than 0.2 MPH.

B. The Inspection Agency shall monitor proof-rolling and compaction operations. This area should then be tested for compaction to a depth of 2.0 feet below the compacted surface prior to the placement of any structural fill material.

C. Refer to Drawings for required sub-grade preparation beneath slabs-on-grade.

3.7 UTILITY TRENCH BACKFILL (AT SLAB ON GRADE LOCATIONS)

A. Excavate and backfill utility trenches under wall footings as shown on the Drawings

B. Place utility base course on subgrades free of mud, frost, snow, or ice.

C. Place and compact utility base course on trench bottoms and where indicated.

D. Lay underground utilities on 6” sand bedding, which meets the acceptable criteria of Section 2.1,B.

E. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

F. After connection joints are made, any misalignment can be corrected by tamping the sand around the utilities.

G. Place and compact initial backfill of acceptable sand to a height of 6 inches over the utility pipe or conduit in 6 inches layer meeting specified compaction requirements.

H. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit.

I. Place and compact final backfill using acceptable soil to final subgrade elevation meeting specified compaction requirements.

J. Backfill voids with acceptable soil while installing and removing shoring and bracing.

K. Inspection Agency shall monitor and test compacted backfill to verify final compaction meets the specified requirement.

3.8 TOLERANCES

A. Top surface of backfilling under paved areas: Plus or minus ½ inch from required elevation.

B. Top surface of general backfilling: Plus or minus 1 inch from required elevation.

END OF SECTION

SECTION 31 23 16

EXCAVATION UNDERCUT

PART 1 - GENERAL

1.1 Section Includes

A. Removing and disposing of unsuitable subgrade soils.

B. Backfilling and compacting undercut area.

PART 2 - PRODUCTS

2.1 Materials

C. Backfill with General/Structural Fill in accordance with Section 31 00 00.

PART 3 - EXECUTION

3.1 Inspection

A. Owner representative will monitor and measure the Excavation Undercut. Restoration of disturbed surfaces to specified lines, grades, and contours.

B. No compensation will be made for Excavation Undercut not monitored by Owner representative.

3.2 Performance

A. Excavate and backfill the Undercut in accordance with Section 31 00 00 and 31 23 26. Maximum depth of undercut is 2 feet unless otherwise approved by Owner.

3.3 Disposal

A. Dispose of unsuitable or excess excavation in the appropriate area as approved by OWNER.

3.4 Dewatering

A. If groundwater is required to be pumped, it shall be pumped to a designated area on-site as approved by OWNER.

3.5 Field Quality Control

A. Representative samples of soils shall be submitted to the Field Engineer and tested for optimum moisture-maximum density determination (ASTM D1557) prior to the start of fill placement. Sample size should be approximately 50 pounds.

B. Field density tests to determine the level of compaction being achieved in the placed soil. The test shall generally be conducted on each lift at the beginning of fill placement and at a frequency mutually agreed upon by the project team for the remainder of the project.

END OF SECTION

SECTION 31 23 26

GENERAL/STRUCTURAL FILL

PART 1 - GENERAL

1.1 Section Includes

A. CONTRACTOR shall place and compact structural fill in the locations shown on the Construction Drawings.

1.2 Related Sections

A. Section 31 00 00 – Earthwork

B. Section 31 23 16 – Excavation Undercut

1.3 References

A. Refer to Geotechnical Exploration Report (CGC, Inc: Project Number C1789, December 7, 2017)

1.4 Description

A. Work in this section covers the following items:

1. Placement of structural fill for construction of the RNG Facility pad.
2. Any areas shown as unsuitable during proof-rolling.

PART 2 - PRODUCTS

2.1 General

A. Provide all materials as shown on the Construction Drawings, as specified herein, and as needed for a complete and proper installation.

B. Fill containing no vegetation, roots, topsoil, peat, ash, wood, or any other non-soil material which by decomposition might cause settlement.

2.2 Structural Fill Materials

A. OWNER will provide soil for structural fill. Structural fill will be from existing on-site stockpiles or will come from soil excavated as part of this Work.

B. Fill includes soils that are native to the project area.

2.3 Other Materials

A. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the CONTRACTOR and approved by the OWNER and ENGINEER.

PART 3 - EXECUTION

3.1 General

A. The CONTRACTOR shall take necessary precautions to protect underground utilities, and especially any utilities whose original cover may be temporarily removed as part of construction.

B. The CONTRACTOR is responsible for securing, purchasing, hauling and placement of fill material meeting the requirements of the Specifications.

3.2 Surface Conditions

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.3 Finish Elevation and Lines

A. Finish to grades shown on Drawings.

3.4 Procedures

A. Protection of Existing Utilities:

1. Unless shown to be abandoned or removed, protect utility lines and other pipes shown on the Construction Drawings or otherwise made known to the CONTRACTOR prior to excavating. CONTRACTOR is required to perform all utility clearances, including interviewing on-site personnel to inquire about existing utilities in areas of proposed excavations If a utility is damaged by the CONTRACTOR, the utility shall be repaired or replaced at no additional cost to the OWNER.
2. If utility lines are encountered that are not shown on the Construction Drawings or otherwise made known to the CONTRACTOR, promptly take necessary steps to assure that service is not interrupted.
3. If service is interrupted as a result of work under this Section, ENGINEER shall be notified, and CONTRACTOR shall immediately restore service by repairing the damaged utility.
4. If existing utilities are found to interfere with the facilities being constructed under this Contract, immediately notify the OWNER and ENGINEER and request their instructions. Maintain a minimum 12-inch horizontal and vertical separation from existing utilities and the facilities being constructed under this contract.
5. Do not proceed with permanent relocation of the work until written instructions are received from the OWNER/ENGINEER.
6. Exposed utilities shall be properly supported at all times if undermined.

B. Protection of Persons and Property:

1. Protect structures, utilities, pavements, and other facilities from damage caused by settlement, lateral movement, washout, and other hazards created by operations under this Section.

C. Dewatering:

1. Remove all water, including rainwater, encountered during work to an approved location by pumps, drains, and other approved methods.
    a. Handling and disposal of water shall comply with all storm water and erosion and sedimentation control permits.

D. Use means necessary to prevent dust becoming a nuisance to the public, to neighbors and to other work being performed on or near the site.

E. Maintain access to adjacent areas at all times.

3.5 Structural Fill Placement

A. Structural fill shall be placed as indicated on the Construction Drawings.

B. Ground Surface Preparation:

1. Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious matter from ground surface prior to placement of structural fill in accordance with the Specifications.

C. Structural Fill Placement and Compaction:

1. Place backfill and fill materials in lifts no more than 10 inches in loose thickness.
2. Compact structural fill using suitable mechanical equipment to achieve a minimum compaction level defined below:

Compaction Guidelines

	Percent Compaction (1)	
Area	Clay/Silt	Sand/Gravel
Within 10 ft of building lines		
Footing bearing soils	93 - 95	95
Under floors, steps and walks		
- Lightly loaded floor slab	90	90
- Heavily loaded floor slab and thicker fill zones	92	95
Beyond 10 ft of building lines		
Under walks and pavements		
- Less than 2 ft below subgrade	92	95
- Greater than 2 ft below subgrade	90	90
Landscaping	85	90

Notes:
1. Based on Modified Proctor Dry Density (ASTM D 1557)

Reference: Geotechnical Exploration Report (CGC, Inc: Project Number C1789, December 7, 2017)

3. Do not place backfill or fill material on surfaces that are muddy, frozen, or containing frost or ice.
4. Rock, stone or broken concrete greater than 6 inches in the largest dimension shall not be placed within 10 feet of the building area.
5. Fill used greater than 10 feet beyond the building limits shall not contain rock, boulders or concrete pieces greater than a 2 square foot area and shall not be placed within the final 2 feet of finished subgrade or in designated utility construction areas.

6. Fill containing rock, boulders or concrete pieces should include sufficient finer material to fill voids among the larger fragments.
7. Place backfill and fill materials evenly adjacent to structures, to required elevations.
8. Hydraulic compaction utilizing water to consolidate soils shall not be allowed.

3.6 Testing of Compacted Soils

A. The ENGINEER will be on-site at all times during the placement of structural fill soil to test the fill during installation.

B. The clay soils shall be tested using a nuclear density moisture gauge in accordance with ASTM D6938.

C. Testing of structural fill will be conducted on each lift at the beginning of fill placement and at the frequency mutually agreed upon by the project team for the remainder of the project. The ENGINEER reserves the right to test any portion of the structural fill areas to verify compaction.

D. Refer to the Table above for compaction requirements of compacted soils.

E. Soil that does not pass initial tests shall be reworked by the CONTRACTOR at no cost to the OWNER until passing results are attained.

3.7 Maintenance

A. Protection of Structural Fill Areas:

1. Protect structural fill areas from traffic and erosion, and keep free from trash and weeds.
2. Repair and reestablish grades in settled, eroded, and rutted areas to the specified tolerances.

B. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify the surface, reshape, and compact to the required density prior to further construction.

PART 4 - MEASUREMENT AND PAYMENT

4.1 NOT USED

* * * END OF SECTION * * *

SECTION 31 23 29

TOPSOIL

PART 1 - GENERAL

1.1 Section Includes

A. Placement of topsoil for upper portion (4 inches) of required Vegetative areas within the limits disturbed by Construction, except for areas designed for roads, pads, and borrow areas.
B. Fertility testing of topsoil.

1.2 Submittals

A. Submit results of nutrients analysis testing on representative samples of topsoil. Testing to include pH, nitrogen, phosphorus, and potassium assessment. Testing results shall be accompanied by a recommendation for fertilizer mixture and application rate to be approved by OWNER. Testing is CONTRACTORs responsibility. Frequency: 1 composite sample per 10 acres of restoration.

PART 2 - MATERIALS

2.1 Topsoil Materials

A. Friable, fertile, loamy soil containing an amount of organic matter normal to the region, capable of sustaining healthy plant life. Free from refuse, subsoil, materials toxic to plant growth, and foreign objects. To be Provide by OWNER.

PART 3 - EXECUTION

3.1 Preparation

A. Remove vegetation, foreign materials, unsatisfactory or contaminated soils, obstructions, and matter harmful to plant growth from ground surface before placement.
B. Prepare subsoil to eliminate uneven areas and low spots. Maintain lines, levels, profiles and contours. Make changes in grade gradual. Blend slopes into level areas.
C. Scarify subsoil where Topsoil is to be placed. Repeat cultivation in areas where equipment used for hauling and spreading Topsoil has compacted subsoil.

3.2 Placement

A. Place Topsoil to a uniform depth of 4 inches. Finish grade should be within plus 0.1 foot of elevations shown on Drawings or thickness required for project areas or as determined by grading tubes.
B. Break down clods and lumps.

3.3 Field Quality Control

A. OWNER will perform under provisions of these Specifications.

* * * END OF SECTION * * *

SECTION 31 23 33

TRENCHING, BACKFILLING, AND COMPACTING FOR UTILITIES AND STORMWATER PIPING

PART 1 - GENERAL

1.1 Summary

A. Trenching, backfilling and compacting for installation of piped utilities.

B. Dewatering, protection, and maintenance of trenches, support of existing structures, sheeting and shoring, hauling and disposal of excess excavated materials and fill.

PART 2 - PRODUCTS

2.1 Backfill Materials

A. Soil Backfill (outside paved / concrete surfaces): General Fill, comply with Drawings.

B. Granular Fill (paved / concrete surfaces): Granular Fill, comply with Drawings

2.2 Bedding Materials

A. For all pipes: Comply with Drawings.

PART 3 - EXECUTION

3.1 Preparation And Restoration

A. Remove sod, topsoil, and other surface treatment and restore to original condition or better upon completion of the Work.

B. Remove snow and ice before excavating.

C. Identify required construction survey control lines and datum.

3.2 Protection

A. Protect excavations by shoring, bracing, sheet piling, or other methods required to prevent cave-in or loose soil from falling into excavation.

B. Place excavated and other material 2 feet minimum back from edge of trench excavation.

C. Minimum trench excavation slope to be 1.5:1 unless otherwise approved by OSHA.

D. Underpin adjacent structures which may be damaged by excavation Work, including utilities and piping.

E. Notify Owner immediately of unexpected subsurface conditions.

F. Protect bottom of excavations and soil adjacent to and beneath foundations from frost.

3.3 Trenching

A. Excavate to required width, alignment and grade. Elevations of pipes maybe subject to revisions, as necessary, to fit field conditions.

B. No adjustment in compensation will be made for grade adjustments less than 1 foot above or below the elevations in the Drawings.

C. Maximum trench width at pipe level shall be outside pipe diameter plus 24 inches.

D. Remove water which may accumulate in trench, and construct ditches, flumes, and dams to direct water away from excavation to areas approved by Owner.

E. Owner may limit the amount of open trench where required by operating conditions.

F. Owner's Representative may order additional excavation where unsuitable soil conditions are encountered. Undercuts performed per Section 31 23 16.

G. Promptly dispose of excess excavation material off-site or in appropriate stockpile area designated by Owner.

3.4 Utility Test Holes

A. Where potential utility or other piping conflicts are anticipated, uncover utility lines / piping well in advance of trench excavation.

B. Determine grade of utility line / piping, if encountered. Owner will advise of the adjustment required.

C. Backfill and restore disturbed area to original condition.

3.5 Bedding

A. Install bedding material from 6 inches below pipe to 12 inches above pipe, unless otherwise indicated on Drawings.

B. Minimum depth of pipe in bedding shall be one third of the outside pipe diameter, unless otherwise indicated on Drawings.

3.6 Backfilling / Compacting

A. Backfill following completion of pipe installation and review by Owner's representative, unless deficiencies are observed. Refer to Piping Sections for piping installation.

B. Take necessary precautions with backfill and construction operations to protect completed system from damage.

C. Backfill with care around structures and cleanouts.

D. Backfill to the original ground elevation unless shown otherwise on Drawings.

E. Place and compact backfill in accordance with Section 31 00 00.

3.7 Field Quality Control

A. OWNER will perform under provisions of these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

(Not Used)

* * * END OF SECTION * * *

SECTION 31 25 00
TEMPORARY EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.1 Work Included

A. Installation of soil erosion control devices.

B. Maintenance of soil erosion devices during construction.

C. Removal of temporary soil erosion control devices after stabilization of disturbed areas.

D. Temporary grassing for soil erosion control.

1.2 References

A. State of Wisconsin Department of Transportation (WisDOT):

1. Standard Specifications for Road and Bridge Construction, latest edition.

B. Erosion Control Product Acceptability Lost (PAL), latest edition.

C. Dane County Erosion Control and Stormwater Management Manual, latest edition

D. State of Wisconsin Department of natural Resources (WDNR)

E. WDNR Technical Standards, latest edition.

F. Dane County No. 2 (Rodefeld) Landfill RNG Facility - Erosion Control Plans

1.3 Quality Control

After installing the soil erosion control devices as called for on the Construction Plans, the CONTRACTOR shall assure himself that all reasonable measures possible have been taken to prevent the siltation of nearby water courses and repair any areas damaged by erosion for a period of 1 year following completion of construction.

PART 2 - PRODUCTS

2.1 SILT FENCE

Posts

A. Silt fence posts shall be post, a minimum of 4.5' long and spaced according to the details in the plans.

Woven Wire Fence

A. Wire fence reinforcement shall be a minimum of 14-gauge 4" x 4" hogwire.

Filter Fabric

A. Use only a synthetic filter fabric that is approved by the Wisconsin Department of Transportation. Synthetic filter fabric should contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six (6) months of expected usable construction life at a temperature of 0 to 120˚F.

2.2 INLET PROTECTION

A. Type B and Type D-M complying with Dane County Standards and WDNR Technical Standard 1060 (Storm Drain Inlet Protection for Construction Sites).

2.3 TRACKING PAD

A. Aggregate base course according to the details in the plans.

2.4 RIP-RAP AND INFILTRATION TRENCHES

A. Stone for rip-rap and infiltration trenches shall be durable, dense, specifically selected and graded quarried stone. The stone shall be the size specified in the plans.

2.5 TEMPORARY SEED

A. Consist of Spring Oats, Sudangrass, Cereal Rye, Winter Wheat or Annual Rye, in accordance with Dane County Technical Standard - Seeding (temporary).

2.6 TURF REINFORCEMENT MAT

A. Turf Reinforcement Mat (TRM) Class III, Type D Turf reinforcement.

B. Anchoring devices for TRM shall be an approved anchoring device recommended by the manufacturer of the product.

2.7 MULCH

A. Comply with Dane County Erosion Control and Stormwater Management Manual, latest edition- Technical Standard Mulching.

PART 3 - EXECUTION

3.1 GENERAL

A. Construct temporary and permanent erosion control measures as shown on the plans, as required by site conditions, regulatory agency or ENGINEER.

B. All permanent erosion control work shall be incorporated into the project at the earliest practicable time.

C. Temporary erosion control measures shall be coordinated with permanent erosion control measures and all other work on the project to assure economical, effective, and continuous erosion control throughout the construction and post construction period and to minimize siltation of rivers, streams, lakes, reservoirs, other water impoundments, ground surfaces, or other property.

D. If active construction ceases for more than 14 days, all disturbed areas shall be seeded and mulched using the temporary seed type and planting rates specified herein. The

CONTRACTOR shall be liable for all damages to public or private property and fines as may be placed on the project by the local regulatory agencies due to soil erosion from the project site. Clear only those areas required to install the soil erosion control devices, request an inspection by the local agency having jurisdiction.

E. All erosion control devices shall be inspected by the CONTRACTOR after each rainfall. Any required repairs shall be made immediately. Sediment deposits shall be removed when deposits reach approximately one-half of the capacity of the erosion control device.

3.2 SILT FENCE

A. Silt fence shall be installed in accordance with the details in the plans.

B. Should the filter fabric deteriorate or become ineffective prior to the end of the construction as determined by the ENGINEER, the fabric shall be replaced immediately at no additional cost to the OWNER.

C. Remove sediment when sediment deposits reach no more than one half of silt fence height.

D. Remove silt fence once contributing drainage are is stabilized with vegetation or impervious area.

3.3 RIP-RAP

A. Prepare subgrade to the required lines and grades as shown or indicated on the contract drawings. Place any fill required in the subgrade to a density equal to that of the surrounding area. Place filter fabric on the finished subgrade.

B. Place rip-rap by mechanical methods, augmented by hand placing where necessary to prevent damage to permanent works, provided that when the rip-rap is completed it forms a properly graded, dense, neat layer of stone. The completed rip-rap shall have a thickness as shown on the plans.

3.4 TEMPORARY GRASSING

A. Temporary grassing procedures will be implemented when directed by the ENGINEER or as required by the soil erosion inspector and in portions of the site where construction activities have temporarily or permanently ceased but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased.

B. Where construction activity will resume on a portion of the site within 21 days from when activities ceased, stabilization measures do not have to be initiated on that portion of the site by the 14th day after construction activity temporarily ceased.

C. Seeding for temporary grassing shall be applied to all shoulders, side ditches, cut slopes, fill slopes, and any other area disturbed by the CONTRACTOR and not designated for pavement or structures. Temporary seeding shall occur immediately following final land disturbing activities. Any unseeded area which erodes shall be repaired to the satisfaction of the ENGINEER at no additional cost to the OWNER. Apply temporary seeding in accordance with the Temporary Seeding rates specified in the Dane County Erosion Control and Stormwater Management Manual, latest edition.

3.5 MULCHING

A. Place mulch on seeded areas within 24 hours after seeding has been completed.

B. Begin mulching at top of slope and proceed downward.

C. Maintain mulched areas and repair any areas damaged by wind, erosion, traffic, or other causes prior to final acceptance of work under contract.

D. Place mulch in accordance with Dane County Erosion Control and Stormwater Management Manual, latest edition- Technical Standard Mulching.

E. Inspect weekly and within 24 hours after each rainfall.

3.6 INLET PROTECTION (AS DIRECTED)

A. A sump shall be constructed around the drop inlet and silt fence installed in accordance with the details in the plans for Inlet Protection.

3.7 TURF REINFORCEMENT MAT (TRM) FOR DITCH

A. The ditch or slope shall be constructed to the configuration shown on the plans.

B. Prepare seedbed and apply lime fertilizer and seed in accordance with grassing specifications.

C. Install TRM in accordance with detail on plans and manufacturer's recommendations.

3.8 REMOVAL OF TEMPORARY EROSION DEVICES

A. The CONTRACTOR shall remove all sedimentation and erosion control devices upon the approval of permanent seeding and stabilization by the agency having jurisdiction of the area and the ENGINEER. All sediment deposits remaining in place after the erosion control devices are removed shall be dressed to conform to the existing grade, prepared, and seeded. The cost of removal and cleanup shall be included in the cost of the installation of the device or in the cost for maintenance.

3.9 CLEAN OUT PERMANENT EROSION CONTROL DEVICES

A. The CONTRACTOR shall clean out permanent sediment and erosion control devices upon approval of permanent seeding and stabilization by the agency having jurisdiction of the area and the ENGINEER. The devices shall be cleaned out to the original condition. The cost of cleanup shall be included in the cost of installation or in the cost of maintenance of the device.

* * * END OF SECTION * * *

SECTION 31 38 00

SITE RESTORATION/SEEDING/VEGETATION

PART 1 - GENERAL

1.1 Summary

A. Provide site restoration as shown and as specified.

B. The work shall include but is not limited to furnishing all labor, equipment and material necessary to final grade, seed, mulch, fertilize, maintain and establish permanent vegetation for the areas as specified herein.

C. Topsoil all areas disturbed by Construction activities within the construction limits, except for areas designed for roads.

D. Fertilize; seed, and mulch top-soiled areas, stockpiles and borrow areas as required.

1.2 Submittals

A. Provide nutrients analysis and nutrient recommendations for topsoil to be used. Testing to include pH, nitrogen, phosphorus, and potassium assessment. Testing is Contractor's responsibility. Frequency: 1 composite sample/10 acres.

B. The Contractor shall submit a complete materials list of items proposed for the work and a description of how the work will be completed.

C. The Contractor shall submit seed and fertilizer certifications for all bags used in the project.

D. Submit letter upon project completion guaranteeing the seed will grow and Contractor will come back in spring of following year to reseed, fertilize, mulch, etc. areas where seed did not take.

1.3 Work Seasons

A. Conduct site restoration during favorable weather conditions*. Do not proceed with any seeding when conditions are not acceptable per seed manufacturer's recommendations. Do not proceed when air temperature exceeds 90 degrees F. or soil temperature is less than 50 degrees F.'

*Consult with owner regarding scheduled dates if weather delays prohibit above dates. Modification to abo e may be made if recommended by seed supplier and approved by Owner.

1.4 Delivery, Storage, and Handling

A. Deliver grass seed in original containers showing analysis of seed mixture, percentage of pure live seed, year of production, net weight, and date of packaging, and location of packaging. Damaged packages are not acceptable.

B. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.5 Maintenance

A. Maintain vegetated surfaces and supply additional topsoil where necessary, including areas affected by erosion.

B. Maintain the proper moisture levels in the seeded areas to stimulate and establish growth.

C. Replant damaged grass areas showing root growth failure, deterioration, bare or thin spots, and eroded areas.

PART 2 - PRODUCTS

2.1 Topsoil

A. Fertile, friable, natural loam surface soil, reasonably free of subsoil, clay lumps, brush, weeds and free of roots, stumps, stones larger than 1” and other extraneous matter harmful to plant growth, containing an amount of organic matter normal to the region, capable of sustaining healthy plant life.

2.2 Fertilizer

A. As required based on nutrient analysis performed on topsoil per Section 31 23 29.

2.3 Seed

A. Deliver in bags tagged and labeled to show percentage of purity and germination. Seed shall have been tested within one year prior to date of seeding and shall conform to latest State and Federal laws. The seed mixes specified below shall be used or other seed mixtures approved by Owner and Engineer. All seed mixtures proposed need to be submitted for approval 20 days prior to use.

B. The following seed mixtures shall be used in the specified locations. Seeding rates shall be 175 lbs/acre unless otherwise specified.

4. Areas: Use WDOT Seed Mix No. 20.
    a. 6 Percent Kentucky Bluegrass
    b. 24 Percent Hard Fescue of Chewings Fescue
    c. 40 Percent Tall Fescue
    d. 30 Percent Perennial Ryegrass

2.4 Straw Mulch

A. Clean Oat/Wheat Straw: Reasonably free of grain, weed seed, or mold. Mulch materials shall not contain excessive moisture which prevents uniform feeding through mulching machine and at least 50% or more of the mulch by weight should be 10” or more in length.

2.5 TURF REINFORCEMENT MAT

A. Turf Reinforcement Mat (TRM) Class III, Type D Turf reinforcement.

B. Anchoring devices for TRM shall be an approved anchoring device recommended by the manufacturer of the product.

2.6 Hydroseed

A. Not allowed on project unless approved by Owner.

2.7 Hydromulch

A. Not allowed on project unless approved by Owner.

PART 3 - EXECUTION

3.1 Examination

A. The Contractor shall not begin work in this section until the final grading has been approved by the Owner.

3.2 Seedbed Preparation

A. The Contractor shall test the topsoil per Section 31 23 29. The test results shall be submitted to the Owner.

B. The seedbed shall be prepared by pulverizing and breaking up the soil to a minimum depth of two inches with a harley rack, or harrowing tool. All rocks over two inches in diameter, clods and undesirable material that would interfere with seeding operations shall be removed.

C. Immediately after seedbed preparation, and if needed as a result of the soil test results and recommendations, the Contractor shall properly apply the recommended appropriate mixtures and quantity of soil amendment/fertilizer to the prepared topsoil layer.

3.3 Seed Application

A. The seeding shall commence immediately after seedbed preparation is complete or as soon thereafter as conditions are favorable.

B. The seed shall be drilled over the seedbed at a rate and depth described in the Dane County Erosion Control and Stormwater Management Manual, latest edition, or as recommended by the seed manufacturer, using methods and drilling equipment acceptable to the seed manufacturer and Owner. Application of grass seed and fertilizer at the same time, in the same machine is not permitted.

3.4 Mulching

A. Upon completion of temporary seeding the approved mulch shall be applied over the seeded area at a rate to be determined by the Contractor to be adequate to protect the seed during germination. If using Straw typical application rate in flat areas is 1.5 tons/acre.

B. If Straw mulch is used it must be crimped in place with a mechanical crimper made for such a purpose, or using a farm-type disc plow sett straight with adequate weight to crimp the material to a depth of approximately 4 inches. If other mulch type material is used in lieu of Straw an appropriate and approved tackifying agent such as asphalt emulsion or similar will be applied to the entire surface at the recommended rate to hold it in place until permanent grass is established.

3.5 TURF REINFORCEMENT MAT

A. Cover seeded slopes where grade is 2:1 or greater with establishment blanket. Roll matting down over slopes without stretching or pulling.

B. Lay matting smoothly on soil surface, burying top end of each section in narrow 69 inch trench. Leave 12 inch overlap from top roll over bottom roll. Leave 4 inch overlap over adjacent section.

C. Staple outside edges and overlaps at 36 inch intervals.

D. Lightly dress slopes with topsoil to ensure close contact between matting and soil.

E. In ditches, unroll matting in direction of flow. Overlap ends of strips 6 inches with upstream section on top.

F. Cover all permanently seeded areas with Excelsior Matting as indicated on the plans.

3.6 Watering

A. Water seeded areas as necessary to assure that moist good growth conditions are maintained until Owner accepts restoration work.

3.7 Protection

A. The Contractor shall secure the work area and protect the vegetated areas from any traffic, disturbances, wildlife, or public use until vegetation is accepted by Owner.

3.8 Establishment & Replacement

A. Seeded areas which fail to show an adequate stand of grass within four weeks shall be raked, reseeded, fertilized, and mulched at Contractor’s expense. Areas seeded in fall, which fail to show an adequate, stand shall be reseeded, fertilized, and mulched the following spring before June 1. Adequate stand shall be considered a minimum of 500 seeding per sq. ft. bare spots shall be no larger than 6” square. Total bare spots shall not exceed 2% of total seeded area.

* * * END OF SECTION * * *

SECTION 32 05 16

AGGREGATE ROAD BASE

PART 1 - GENERAL

1.1 Section Includes

A. Gravel Area Sections, and

B. RNG Facility Slabs.

1.2 Submittals

A. Submit test results under provisions of Section 01 00 00, indicating that proposed materials meet the required specifications.

B. Submit source of supply and test results from an accredited testing laboratory under provisions of Section 01 00 00. Submit request for substitution under provisions of Section 01 00 00.

PART 2 - PRODUCTS

2.1 Gravel Area Sections and Pad Construction Materials

A. Aggregate Base: Crushed stone or gravel meeting requirements of WISDOT Std. Spec., Section 305, for 1-1/4 in. base.

2.2 Pavement Area Materials

A. Dense Graded Base Course (DGB): Crushed stone or gravel meeting requirements of WISDOT Standard. Specification, Sections 305 and 301, for 1-1/4 inch base and 3 inch base.

PART 3 - EXECUTION

3.1 Inspection

A. Owner's representative to observe proof-rolling and approve subgrade prior to Aggregate Surface Course placement.

B. Rework subgrade or re-compact as necessary.

3.2 Installation

A. Aggregate Surface Course: Deposit Aggregate Base Course material in a manner to minimize segregation and facilitate spreading to a uniform uncompacted layer. Construct the Aggregate Base Course in one or more layers. All Gravel Area Sections and facility pad of 12" aggregate base course placed in 2 compacted 6-inch lifts.

B. Aggregate beneath pavement sections consist of 10-inches DBE shall consist of a minimum of 4-inches of 1-1/4 inch DGB and 6 inches of 3-inch DGB.

C. Add water as necessary to assist compaction. If excess water is apparent, aerate Aggregate Base Course material to reduce the moisture content.

D. Compact each layer of material to the degree that no further appreciable consolidation or movement of the base is evidenced under action of the compaction equipment. Compact each layer of Aggregate Base Course to a minimum of 95% of the materials modified Proctor value.

E. Rework or remove and replace soft or yielding areas as required until proper compaction is obtained. The cost of such reworking or removal and replacement shall be at the CONTRACTOR's expense.

3.3 Field Quality Control

A. OWNER will perform under provisions of these Specifications.

* * * END OF SECTION * * *

SECTION 32 12 16

ASPHALT PAVING

PART 1 - GENERAL

1.1 Section Includes

A. Mixing, spreading, compacting, and finishing of bituminous pavements for base, leveling, and surface courses on roads, parking lots, and other areas.

1.2 Quality Assurance

A. Perform work in accordance with the State of Wisconsin Department of Transportation — Standard Specifications for Highway and Structure Construction, 2018 Edition, hereinafter referred to as "WISDOT Specifications." Measurements and payments portions of those WISDOT Specifications do not apply to work performed under this contract.

B. Mixing Plant: Comply with requirements of WISDOT Specifications.

C. Qualifications of Asphaltic Concrete Producer: Use only materials which are finished by a bulk asphaltic concrete producer regularly engaged in production of hot-mix, hot-laid asphaltic concrete.

1.3 Paving Quality Requirements

A. General: In addition to other specified conditions, comply with the following minim requirements.

1. Test in-place asphaltic concrete courses for compliance with requirements for density, thickness, and surface smoothness.
2. Provide final surfaces or uniform texture, complying with required grades and cross-sections.
3. Take not less than 4-inch diameter pavement specimens for each completed course, from locations as directed by the testing agency.
4. Repair holes from test specimens as specified for patching defective work.

B. Density

1. Compare density of in-place material against laboratory specimens of same asphaltic concrete mixture, when subjected to 50 blows of standard Marshall Hammer on each side of specimen.
2. Minimum acceptable density of in-place course material is 96% of the recorded laboratory specimen density.

1.4 Regulatory Requirements

A. Comply with all applicable local standards, codes, and ordinances for paving work on public property.

1.5 Submittals

A. Samples: Provide samples of materials for laboratory testing and job-mix design as required by OWNERs Representative.

B. In lieu of laboratory test reports, CONTRACTOR may provide certificates signed by the asphaltic concrete producer and CONTRACTOR certifying that materials comply with all specification requirements.

1.6 Environmental Requirements

A. Do not place asphalt when the base surface temperature is less than 40°F.

B. Do not apply materials when substrate is wet or contains sufficient moisture to prevent uniform distribution and proper penetration.

PART 2 - PRODUCTS

2.1 Materials

A. Tack Coat: Emulsified asphalt SS-1, diluted with equal parts of water.

B. Asphalt Cement: AASHTO M320-10, 82-34 performance graded asphalt binder.

C. Stone Base: Dense graded base course in accordance with WISDOT Specification Sections 301 and 305.

1. Coarse aggregate: 3 inch
2. Fine aggregate: 1 1/4 inch

D. Mineral Filler: Shall meet the requirements of AASHTO M17 finely ground particles of limestone, hydrated lime, Portland cement, or other approved mineral dust, free from foreign matter.

2.2 Asphalt Paving Mix

A. Use dry materials to avoid foaming. Mix uniformly.

B. Mix designation: WISDOT Specification Sections as follows:

1. Asphaltic Concrete Surface Course: Section 460, LT bituminous with grading No. 5
2. Binder Course: Section 460, LT bituminous with grading No. 4

C. The pavement shall be constructed in accordance with the Wisconsin State DOT Standard Specifications for Highway and Structure Construction, latest edition, including supplemental specifications and Wisconsin Asphalt Pavement Association 2016 Asphalt Pavement Design Guide.

PART 3 - EXECUTION

3.1 Inspection

A. Verify compacted sub-grade is dry and ready to support paving and imposed loads.

B. Verify gradients and elevations of base are correct.

C. Beginning of installation means acceptance of substrate.

3.2 Preparation

A. Prepare mix materials and place of deposit in accordance with referenced WISDOT specifications.

B. Tack Coat:

1. Apply tack coat only when the air temperature is 32°F or more unless the otherwise approved by ENGINEER. Before applying tack coat ensure that the surface is reasonably free of loose dirt, dust, or other foreign matter. Do not apply to surfaces with standing water. Do not apply if weather or surface conditions are unfavorable or before impending rains.
2. Apply tack coat to contact surfaces of concrete items, which abut pavement.
3. Apply to contact surfaces of existing asphalt or concrete pavement at the rate of 0.050 – 0.070 gallons per square yard of surface. ENGINEER may adjust application rate based on surface conditions. Limit application each day to the area the contractor expects to pave during that day.

C. Frames and subsurface structures:

1. Coat Surfaces of new and existing frames with oil to prevent bond with asphalt paving.
2. Set to be flush with finish surface and surround with a ring of compacted asphaltic concrete to one inch below top of frame. Adjust as required to meet paving.
3. Provide temporary covers over openings until completion of rolling operations.

3.3 Placing Asphalt Pavement

A. Place materials in accordance with referenced WISDOT Specifications.

B. Place, spread, and strike-off to compacted thickness indicated with paving machine, except that inaccessible and small areas may be placed by hand.

C. Place topping course within 2 hours of placing and compacting binder course.

D. Compact pavement by rolling. Do not displace or extrude pavement from position. Hand compact area inaccessible to rolling equipment.

1. Average relative density: Minimum of 96%
2. Individual relative density: Minimum of 92%

E. Develop rolling with consecutive passes to achieve even and smooth finish of uniform texture, without roller marks.

F. Make joints between successive days work, or between old and new pavements in accordance with referenced State Highway Specification. Ensure a continuous bond is attained.

3.4 Tolerances

A. Flatness: ± 0.25 inch measured with a 10-foot straight edge.

B. Compacted scheduled thickness: ± 0.15 inch of design thickness.

C. Variation from true elevation: 0.05 feet.

3.5 Patching

A. Remove defective or deficient areas for full depth of course.

1. Cut sides parallel and perpendicular to direction of traffic with edges vertical.
2. Apply tack coat to exposed surfaces and place asphalt on prepared surfaces as specified above.

3.6 Field Quality Control

A. Field inspection and testing will be performed by OWNER as described under provisions of these Specifications and the CQA Plan.

3.7 Protection

A. Immediately after placement, protect pavement from mechanical injury for 7 days.

B. Cover openings of substrate structures in paved area until permanent coverings are placed.

3.8 Schedule of Pavement Sections

A. Place and compact materials to the thickness called for on the Construction Drawings.

* * * END OF SECTION * * *

SECTION 32 13 05

CONCRETE PAVEMENT

PART 1 GENERAL

1.01 SUMMARY

A. Provide concrete pavement, including prepared base, as shown and as specified. Comply with applicable provisions of Divisions 00 and 01.

1.02 DEFINITIONS

A. References to "WISDOT Std. Spec." shall mean Wisconsin Department of Transportation, Standard Specifications for Highway and Structure Construction, latest edition, including current Supplemental Specifications.

1.03 NOTIFICATION

A. Notify A/E at least 24 hr prior to placing any concrete.

1.04 SUBMITTALS

A. Mix Design: Submit mix design for review at least 10 days prior to use. Mix design shall be derived from tests performed by a qualified testing laboratory or from previous tests performed on aggregate from same source.

B. Joint Plan: If joint locations are not shown on Drawings, submit jointing plan in accordance with "Joints" article, below.

C. Product Data and Certificates of Compliance: Submit product data and material certifications for joint fillers and sealers.

D. Test Reports: Submit reports for laboratory and field tests required under "Testing" article. Test reports for base course shall be submitted prior to placing concrete pavement.

E. Make submittals in accordance with Section 01.

1.05 TESTING

A. Contractor shall arrange and pay for base course compaction testing by a qualified testing agency, acceptable to Owner and independent of Contractor. Determine laboratory density of base course material. Perform at least one field density test for every 2,000 sq ft of paved area, but in no case less than three tests.

PART 2 PRODUCTS

2.01 BASE COURSE

A. Crushed stone or crushed gravel meeting requirements of WISDOT Std. Spec., Section 305, for 1-1/4 in. base.

2.02 CONCRETE

A. Concrete shall be in accordance with Section 03 30 00, Class AA.

Class	Min, Comp Strength @ 28 days, p.s.i.	Max Slump	Max. Agg. Size	Min. Cement, Bags/C.Y.	Max. Water-Cement Ratio	Air Content % by Volume
AA	4,500	3-1/2”	¾”	6	0.45	5-7%*

*1-1/2” max. aggregate size may be used if allowed by ACI 318. If used, air entrainment shall be 4-6%.

2.03 REINFORCING STEEL

A. Reinforcing Bars and Tie Bars: ASTM A615, Grade 60, deformed steel bars, epoxy-coated in accordance with ASTM A775.

2.04 FORMS

A. Provide forms of steel, wood, or other suitable material of size and strength to resist movement during concrete placement and to retain horizontal and vertical alignment until removal. Use straight forms, free of distortion and defects, extending full depth of concrete.

B. Use flexible spring steel forms or laminated boards to form radius bends as required.

C. Coat forms with a form release agent which will not discolor or deface surface of concrete.

2.05 JOINT MATERIALS

A. Expansion joint filler (1/2 in. thick, unless otherwise indicated) meeting requirements of WISDOT Std. Spec., Subsection 415.2.

B. Joint sealer shall be hot-poured elastic type or cold-poured silicone type. Hot-poured elastic sealant shall comply with ASTM D6690, Type II. Cold-poured silicone sealant shall comply with ASTM D5893, Type SL.

2.06 CURING COMPOUNDS

A. Curing compounds and curing agents meeting requirements of WISDOT Std. Spec., Subsection 415.2.

2.07 TRAFFIC MARKING PAINT

A. Factory mixed, non-bleeding, waterborne traffic marking paint complying with FS TT-P-1952, Type II, with a drying time of less than 45 minutes. Color shall be white, except where yellow is designated.

PART 3 EXECUTION

3.01 PREPARATION

A. Shape and compact subgrade to uniform density and to required alignment and cross-section. Foundation shall be smooth and at proper elevation and contour to receive base course.

B. Whenever new work adjoins existing pavement, saw cut existing pavement to form a straight, vertical joint line.

3.02 PLACING BASE COURSE

A. Place base course to grade as shown with proper allowance for concrete pavement. Base course shall be compacted to 95% maximum density at optimum moisture content in accordance with ASTM D698 or AASHTO T99.

B. Base course in excess of 8 in. thickness shall be compacted in two lifts.

3.03 PAVEMENT CONSTRUCTION

A. Construct concrete pavement in accordance with Section 03 30 00 and WISDOT Std. Spec., Subsection 415.3, except as otherwise designated.

B. Slope pavement as shown on Drawings.

C. Final surface finish shall be light brush finish.

3.04 JOINTS

A. Locate joints where shown on Drawings. If not shown, prepare and submit a jointing plan based on the following:

1. Locate contraction joints at a maximum of 15 ft. on center each way. Joints shall be continuous across slab, unless interrupted by an expansion joint. Extend joints completely through curb. Saw joints to the initial and final configuration shown.
2. Locate expansion joints as required to isolate fixed objects abutting or within paved area.

B. Provide tie bars and dowel bars as follows:

1. At construction joints, provide No. 6 tie bars, 2'-0" long, spaced 1'-0" o.c. and centered vertically in pavement.

C. Install expansion joint materials in accordance with manufacturer's recommendations.

3.05 SEALING JOINTS

A. Seal construction, contraction, and expansion joints with joint sealer placed in accordance with manufacturer's recommendations.

B. Seal shall be 1/2 to 5/8 in. wide and 3/4 in. deep, with backer rod as required.

3.06 PROTECTION

A. Properly protect work by barricades to prevent damage to freshly placed concrete until pavement has cured.

3.07 LANE AND PARKING MARKING

A. Paint line work on concrete paving and concrete curbs as designated by Owner.

B. Clean surface in areas to receive markings. Paint markings and symbols with traffic marking paint. Apply paint with mechanical equipment to produce uniform straight edges. Apply one coat at manufacturer's recommended rate to achieve a minimum wet film thickness of 15 mils.

END OF SECTION

SECTION 32 31 10

CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 SUMMARY

A. Provide chain link fences, gates, and appurtenances as shown and as specified. Comply with applicable provisions of Divisions 00 and 01.

1.02 SUBMITTALS

A. Shop Drawings: Submit shop drawings for fence, gates, and appurtenances. Include plan layout; fence height; location and sizes of posts, rails, braces, gates and footings; product data; and erection procedures.

1.03 QUALITY ASSURANCE

A. Provide chain link fence and gates as a complete unit produced by a single manufacturer, including necessary erection accessories, fittings, and fastenings.

PART 2 PRODUCTS

2.01 FABRIC

A. Fabric shall be 9 gage (0.148 in.) steel wire in a 2-in. mesh. Fabric 5 ft high and under shall be knuckled at both selvages. Fabric 6 ft and over shall be knuckled at one selvage and twisted and barbed at other selvage. Provide one-piece fabric widths for fence up to 12 ft.

B. Fabric shall be one of the following:

1. Aluminum-coated before weaving, ASTM A491, with not less than 0.40 oz aluminum per sq ft of surface.
2. Galvanized before or after weaving, ASTM A392, Class 2, with not less than 2.0 oz zinc per sq ft of surface.

B. Fabric shall be galvanized before or after weaving, ASTM A392, Class 1, with not less than 1.2 oz zinc per sq ft of surface.

B. Fabric shall have minimum 6 mil PVC plastic resin finish, ASTM F668, Class 2, thermally bonded to galvanized steel; color as selected by Owner.

2.02 FRAMEWORK, GENERAL

A. Framework shall be steel. Strength requirements shall conform to ASTM F1043.

B. Pipe sizes indicated are commercial pipe sizes. Tube sizes are nominal outside dimension. H-section sizes are nominal flange dimensions. Roll-formed section sizes are nominal outside dimensions.

C. Steel framework and appurtenances shall be galvanized as follows:

1. Pipe: ASTM F1083 (1.8 oz. zinc psf).
2. Square Tubing, H, and Formed Sections: ASTM A123 (2.0 oz zinc psf).
3. Hardware and Accessories: ASTM A153 (zinc weight per Table I).

2.03 POSTS

A. End, corner, and pull posts shall be of minimum sizes and weights as follows:

1. Up to 6-ft fabric height:
    a. 2.375-in. O.D. pipe weighing 3.65 plf.
    b. 2-in. square tubing weighing 3.60 plf.
    c. 3.5-in. x 3.5-in. roll-formed section weighing 4.85 plf.
2. Over 6-ft fabric height:
    a. 2.875-in. O.D. pipe weighing 5.79 plf.
    b. 2.5-in. square tubing weighing 5.10 plf.
    c. 3.5-in. x 3.5-in. roll-formed section weighing 4.85 plf.

B. Line posts shall be of minimum sizes and weights as follows:

1. Up to 6-ft fabric height:
    a. 1.90-in. O.D. pipe weighing 2.72 plf.
    b. 1.875-in. x 1.625-in. H-section weighing 2.70 plf.
    c. 1.875-in. x 1.625-in. roll-formed section weighing 2.28 plf.
2. Over 6-ft fabric height:
    a. 2.375-in. O.D. pipe weighing 3.65 plf.
    b. 2.25-in. x 1.70-in. H-section weighing 3.26 plf.
    c. 2.25-in. x 1.70-in. roll-formed section weighing 2.70 plf.

C. Gate posts for supporting single gate leaf, or one leaf of a double gate installation, for nominal gate widths shall be as follows:

1. Up to 6-ft wide:
    a. 2.875-in. O.D. pipe weighing 5.79 plf.
    b. 2-1/2-in. square tubing weighing 5.10 plf.
    c. 3-in. x 3-in. H-section weighing 6.50 plf.
    d. 3.5-in. x 3.5-in. roll-formed section weighing 4.85 plf.
2. Over 6 to 13-ft wide:
    a. 4.0-in. O.D. pipe weighing 9.11 plf.

2.04 TOP RAILS

A. Top rails, unless otherwise shown, shall be as follows:

1. 1.660-in. O.D. pipe weighing 2.27 plf.
2. 1.625-in. x 1.25-in. roll-form sections weighing 1.35 plf.

B. Furnish in manufacturer's longest lengths, with expansion type couplings approximately 6-in. long for each joint. Provide means for attaching top rail securely to each gate, corner, pull, and end post.

2.05 BRACES

A. Use 1.660-in. O.D. pipe weighing 2.27 plf for horizontal braces and 3/8-in. diameter rod with turnbuckle for diagonal trusses.

B. Provide bracing assemblies at end and gate posts and at both sides of corner and pull posts, with horizontal brace located at mid-height of fabric. Provide manufacturer's standard galvanized steel or cast iron cap for each end.

2.06 TENSION WIRE

A. 7 gage coil spring steel wire, finish to match fabric.

2.07 WIRE TIES

A. 9 gage steel wire or 6 gage preformed steel clips, finish to match fabric.

2.08 STRETCHER BARS

A. One piece lengths with minimum length 2 in. less than full height of fabric, with a minimum cross-section of 3/16 in. x 3/4 in. Provide one stretcher bar for each gate and end post, and two for each corner and pull post, except where fabric is integrally woven into post.

2.09 POST TOPS

A. Steel, wrought iron, or malleable iron, designed as a weather tight closure cap (for tubular posts). Provide one cap for each post. Furnish caps with openings to permit through passage of top rail.

2.10 GATES, GENERAL

A. Fabricate perimeter frames of gates from metal and finish to match fence framework. Assemble gate frames by welding. Provide horizontal and vertical members to ensure proper gate operation and attachment of fabric, hardware, and accessories. Space frame members maximum of 8 ft apart, unless otherwise indicated.

B. Provide same fabric as for fence, unless otherwise indicated. Install fabric with tension bars and bands at vertical edges and at top and bottom edges.

C. Install diagonal cross-bracing consisting of 3/8-in. diameter adjustable-length truss rods on gates to ensure frame rigidity without sag or twist.

D. Where barbed wire is indicated above gates, extend end members of gate frames 12 in. above top member and prepare to receive three strands of wire. Provide necessary clips for securing wire to extensions.

2.11 SWING GATES

A. Swing gates shall comply with ASTM F900.

B. Gate frame members shall be as follows:

1. Up to 6-ft high, leaf width 8-ft or less:
   a. 1.66-in. O.D. pipe weighing 2.27 plf.
   b. 1.5-in. square tubing weighing 1.90 plf.
2. Over 6-ft high and 8-ft wide:
   a. 1.90-in. O.D. pipe weighing 2.72 plf.
   b. 2-in. square tubing weighing 2.60 plf.

C. Hinges shall be pressed or forged steel or malleable iron to suit gate size, non-lift-off type, offset to permit 180 deg gate opening. Provide 1-1/2 pair of hinges for each leaf over 6-ft nominal height.

D. Latch shall be forked type or plunger-bar type to permit operation from either side of gate. Provide padlock eye as integral part of latch.

E. Provide keeper for all vehicle gates, which automatically engages gate leaf and holds it in open position until manually released.

F. Provide gate stops for all double gates, consisting of mushroom type flush plate with anchors. Set in concrete to engage center drop rod or plunger bar. Provide locking device and padlock eyes as an integral part of latch, permitting both gate leaves to be locked with a single padlock.

2.12 CONCRETE

A. Comply with Section 03 30 00.

PART 3 EXECUTION

3.01 INSTALLATION, GENERAL

A. Install fence in compliance with ASTM F567. Do not begin installation and erection before final grading is completed, unless otherwise permitted.

3.02 EXCAVATION

A. Excavate post holes to minimum diameters as recommended by fence manufacturer, but not less than four times largest cross-section of post. Space line posts evenly, 10 ft or less apart, unless otherwise indicated.

B. Excavate holes approximately 3 in. lower than post bottom, with bottom of posts set not less than 36 in. below surface when in firm, undisturbed soil. Excavate deeper as required for adequate support in soft and loose soils, and for posts with heavy lateral loads.

C. Spread soil from excavations uniformly adjacent to fence line, or on adjacent areas of site, as directed.

3.03 SETTING POSTS

A. Remove all loose and foreign materials from sides and bottoms of holes, and moisten soil prior to placing concrete.

B. Center and align posts in holes 3 in. above bottom of excavation.

C. Place concrete around posts in a continuous pour, and vibrate or tamp for consolidation. Check each post for vertical and top alignment; hold in position during placement and finishing operations.

D. Trowel finish tops of footings, and slope or dome to direct water away from posts. Extend footings for gate posts to underside of bottom hinge. Set keeps, stops, sleeves and other accessories into concrete as required.

E. Keep exposed concrete surfaces moist for at least 7 days after placement, or cure with membrane curing material, or other acceptable curing method.

3.04 FENCE ERECTION

A. Allow concrete to attain at least 75% of its minimum 28 day compressive strength, but in no case sooner than 7 days after placement, before rails, tension wires, barbed wire, or fabric are installed. Do not stretch and tension fabric and wires, and do not hang gates, until concrete has attained its full design strength.

B. Run top rail continuously through post caps or extension arms, bending to radius for curved runs. Provide expansion couplings as recommended by fencing manufacturer.

C. Install braces so posts are plumb when diagonal rod is under proper tension.

D. Install tension wire within 6 in. of bottom of fabric before stretching fabric and tie to each post with not less than same gage and type of wire. Pull wire taut, without sags. Fasten fabric to tension wire with 11-gage hog rings of same material and finish as fabric wire, spaced maximum 24 in. o.c.

E. Leave approximately 2 in. between finish grade and bottom selvage, unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Install fabric on security side of fence, and anchor to framework so that fabric remains in tension after pulling force is released.

F. Thread stretcher bars through or clamp to fabric 4 in. o.c., and secure to posts with metal bands spaced 15 in. o.c.

G. Tie fabric to line posts with wire ties spaced 12 in. o.c. Tie fabric to rails and braces with wire ties spaced 24 in. o.c. Tie fabric to tension wires with hog rings spaced 24 in. o.c. Use U-shaped wire, conforming to diameter of pipe to which attached, clasping pipe and fabric firmly with ends twisted at least two full turns. Bend ends of wire to minimize hazard to persons or clothing.

H. Install nuts for tension band and hardware bolts on side of fence opposite fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

I. Install gates plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage, as recommended by fence manufacturer. Adjust hardware for smooth operation and lubricate where necessary.

J. Repair damaged coatings in accordance with manufacturer's recommendations.

END OF SECTION

SECTION 33 32 26

SUBMERSIBLE PUMP LIFT STATION

PART 1 GENERAL

1.01 SUMMARY

A. Provide lift station, complete with submersible leachate pumps, piping, and appurtenances, as shown and as specified. Comply with applicable provisions of Division 00.

1.02 RELATED SECTIONS

Division 26 - Electrical.
40 05 33 HDPE Pipe

1.04 SUBMITTALS

A. Shop Drawings: Submit shop drawings for pumps and accessories.

B. O/M Manuals: Submit O/M manuals for pumps.

C. Test Report: Submit written report for factory pump test.

D. Startup Letter: Submit service representative's letter concerning startup services.

E. Warranty: Submit written warranty for pump.

F. Make submittals in accordance with Section 01 00 00.

1.05 WARRANTY

A. Pump manufacturer shall warranty pump workmanship and materials in accordance with its standard 5-year limited warranty.

PART 2 PRODUCTS

2.01 LIFT STATION, GENERAL

A. Provide totally submersible, electrically operated, leachate pumps with hydraulic sealing discharge connection, and pump lifting wire with hooks. Provide piping, valves and accessories, as designated.

B. Design shall be such that pumps will be connected to discharge piping when lowered into place. Pumps shall be easily removable for inspection or service, requiring no bolts, nuts or other fastening devices to be removed, and no need of personnel to enter pump well.

C. Pumps and motors shall be UL-Approved for use in Class I, Div. 1, Group D hazardous location as defined by National Electrical Code.

E. Miscellaneous metals and hardware within lift station wet well shall be stainless steel.

2.02 PUMPS

A. Acceptable Manufacturers: EPG, QED, or approved equal.

B. Each pump shall have capacity of 20 gpm at total design head of 55 ft. Each pump motor shall be 1/2 hp (maximum), 230 v, 3 ph, 60 hz, service.

C. Pump motors shall have cooling characteristics suitable to permit continuous operation in totally, partially, and non-submerged conditions. Motors shall have integral overload element embedded in winding to protect motor against overcurrent and overheating due to overload and failure to start. Overload element shall automatically reset when motor cools.

D. Pump motor power and control cables shall be provided by pump supplier. Cables shall be neoprene or PVC jacketed and suitable for submersible wastewater and landfill applications. Power cable shall have ground wire and be of size as recommended by manufacturer and as required by code. Control cables shall be of size and number of conductors as required to perform functions specified. Cables shall be potted into a steel connector with polyurethane resin, or other suitable means shall be used to provide a leakproof seal.

E. Power cable and control wiring shall be of sufficient length to reach control panel without splices and shall allow complete removal of pumps from pump well without disconnection of wiring.

2.03 PUMP TEST

A. Manufacturer shall perform standard inspections and tests before shipment; submit a written report of test data.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install pumps and accessories in accordance with shop drawings and manufacturer's recommendations. Mount equipment as indicated on Drawings.

C. Extend piping and terminate with a suitable coupling adapter to mate with discharge force main.

3.02 OPERATION OF SYSTEM

A. Electrical connections and controls will be provided under Division 26.

3.03 MANUFACTURER SERVICES

A. Equipment manufacturer shall provide services of a factory-trained service representative for a minimum of 1 day to:

1. Review the installation.
2. Check and adjust equipment prior to operation.
3. Check integral equipment supplied by other manufacturers.
4. Observe field tests of equipment.
5. Train Owner's operator(s) in operation of equipment.

B. Notify A/E and Owner when this initial service will be performed.

C. After start-up of equipment, service representative shall furnish a letter to A/E and Owner confirming that the installation is in accordance with manufacturer recommendations, necessary alignments and adjustments have been made, and equipment is operating properly.

D. In addition to initial services, manufacturer shall provide for a 1-day inspection trip after 6 months of operation to inspect and adjust equipment.

3.04 SYSTEM TESTS

A. Prior to acceptance, conduct an operational test, under observation of A/E, to demonstrate that installed equipment meets purpose and intent of Specifications. Performance shall be demonstrated throughout operating range.

B. Demonstrate that equipment is not defective electrically, mechanically, or otherwise, and is in a safe and satisfactory operating condition.

C. Check for excessive vibration, leaks in piping and seals, electrical power input in kilowatts, and correct operation of control system and equipment.

END OF SECTION

SECTION 33 42 00

CULVERTS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Culverts as shown and specified.

1.2 SUBMITTALS

A. Submit shop drawings of culverts.

PART 2 PRODUCTS

2.1 MATERIALS

A. Culvert pipe shall be of material and type indicated in the Drawings or Special Provisions. If not designated, select one of the materials listed below. Each pipe shall be stamped or indelibly marked with its type and class and the manufacturer's name or mark.

B. CORRUGATED STEEL PIPE AND PIPE ARCH CULVERTS

1. Corrugated steel pipe (CSP) and corrugated steel pipe arch (CSPA) shall conform to AASHTO M36/ASTM A760, except reinforcement of ends is not required. Provide accessories as shown.

2. Corrugations shall be annular or helical, minimum size 2-2/3 in. x 1/2 in. Minimum sheet thickness for steel material shall be as follows:

Circular Pipe		Pipe Arch	
Dia. (in.)	Min. Gage	Dia. (in.)	Min. Gage
12 to 24	16	17 x 13 to 28 x 20	16
30 to 36	14	35 x 24 to 42 x 29	14
42 to 54	12	49 x 33 to 64 x 43	12
60	10	71 x 47	10

C. REINFORCED CONCRETE PIPE AND PIPE ARCH CULVERTS

1. Reinforced concrete pipe (RCP) shall conform to AASHTO M170/ASTM C76, Class III, unless otherwise indicated. Reinforced concrete pipe arch (RCPA) shall conform to AASHTO M206/ASTM C506, Class A-III, unless otherwise indicated. Size per Drawings.

D. CORRUGATED POLYETHYLENE PIPE CULVERTS

1. Corrugated polyethylene (PE) pipe shall conform to AASHTO M294, Type S, having a corrugated outer wall and smooth inner liner. Size per Drawings

PART 3 EXECUTION

3.1 INSTALLATION

A. Contractor shall be responsible for temporary drainage during installation.

B. Install culverts in open trenches to line and grades as shown.

C. Where culverts are located in new embankments, grade shall be brought up to at least as high as the top of culvert and shall not exceed 2 ft above top of culvert when culvert is installed.

D. Excavate trench sides as nearly vertical as possible. From bottom of trench to an elevation 1 ft above top of culvert, trench width shall not exceed diameter of pipe plus 24 in. Bottom of trench shall be shaped by hand methods or by a suitable template so that lower one-tenth of diameter of culvert will be in contact with bottom of trench. For concrete pipe, excavate for bell holes. Culverts shall be bedded with existing materials, unless otherwise indicated.

E. Where rock, hardpan, or boulders are encountered at bottom of trench excavation, excavate an additional 8 in. below bottom of culvert and backfill with granular materials approved by A/E.

F. INSTALLING CULVERT SECTIONS

1. Lay riveted corrugated steel culverts so that flow is over lap of sheets. Lay concrete pipe with bell or grooved ends facing upstream.

2. Culverts shall be placed in a straight line, and at a grade which will accurately maintain the bed of water course or channel. Allow a slight camber in middle of length so that after completion of additional embankment above pipe there will be no sags or depressions in entire length of culvert.

3. Corrugated steel pipe sections shall be joined with a band bolted into place in accordance with manufacturer's directions. Concrete pipe sections shall be carefully fitted together so that joints are tight and preclude infiltration of surrounding soil. Corrugated polyethylene pipe shall be joined with a soil-tight coupling in accordance with manufacturer's directions.

G. BACKFILLING

1. Backfill with select excavated material, free from large lumps, rocks, rubbish, wood, organic material and frozen material. Carefully place backfill on both sides of culverts and structures in layers not exceeding 6 in. depth. Thoroughly tamp and compact each layer to density of surrounding soil. Place successive 6 in. layers to an elevation 12 in. above top of pipe.

2. Remaining backfill may be deposited from top of trench by mechanical means. Backfill material in no case shall be dropped from such height or in such a volume that its impact upon pipe will cause damage.

3. Compact backfill under roadways and walks to 95% of Standard Proctor density (ASTM D698). Compact backfill elsewhere to 90% of Standard Proctor density.

4. A minimum depth of 2 ft of earth cushion shall be maintained over top of covered pipes during succeeding operations until placement of base or surface courses.

END OF SECTION

SECTION 33 56 22

STEEL ABOVEGROUND STORAGE TANKS

PART 1 GENERAL

1.01 SUMMARY

A. Provide steel aboveground storage tanks as shown and as specified. Comply with applicable provisions of Divisions 00 and 01.

1.03 ABBREVIATIONS

AWWA – American Water Works Association

1.04 SUBMITTALS

A. Product Data: Submit product data for tanks and accessories.

B. O/M Manuals: Submit operation and maintenance manuals for equipment.

C. Make submittals in accordance with Section 01.

1.07 WARRANTY

A. Tank manufacturer shall warranty pump workmanship and materials in accordance with its standard warranty against leakage from corrosion.

PART 2 PRODUCTS

2.01 STEEL TANK

A. CST Storage Tank - 11.00 Foot Diameter x 17.76 Foot nominal sidewall height factory coated welded carbon steel Fire Protection Tank. Nominal Capacity 12,626 gallons and designed to store water for fire protection and designed in accordance with CTT Specifications, Seismic Zone 0 per AWWA, 115 MPH wind load per AWWA, 25 PSF live deck load. Flat bottom, anchoring stirrups with anchor bolts (cast in place type), design pressure 8.00 oz., vacuum 1.00 oz. per square inch, 10 degree deck slope. Hot Rolled Sheet and Plate – ASTM A1011 Grade 40 or Equal. Structural Shapes – ASTM A36 or ASTM A992.

B. Coatings:

Interior coating: Expoxy, 2.0 mils AVG DFT per SSPC PA-2

Exterior Primer: Expoxy, 2.0 mils AVG DFT per SSPC PA-2

Exterior Topcoat: Performance Urethane, 1.5 mils AVG DFT

Coatings are applied over an SSPC-SP 6 commercial blast and thermally cured. All CST Storage costing are to be applied within a controlled environment and blast is achieved using steel grit.

C. Accessories

1. Welding: Class 1:

2. Cylinder: All vertical and circumferential welds shall be full penetration double-butt welds.
3. Skirt: Same as cylinder
4. Deck to cylinder: Double fillet weld
5. Hopper to cylinder: Full penetration single bevel weld
6. Appurtenances & nozzles: Double fillet weld
7. Interior grind requirements: CTT standard - smooth not flush

D. Other Accessories:

1- CST Storage decal installed on top ring
2- 24" Diameter shell manway with bolt-on hinged cover
1- Mushroom vent with 1/2" mesh screen
1- 24" Square roof manway with hinged cover
1- Name Plate, Liquid Tank
1- 4" Diameter 150# FFSO single flanged nozzle
1- 4" Diameter 150# FFSO single flanged nozzle
1- 4" 150# FFSO Flanged nozzle with elbow and vortex breaker
1-6" Overflow assembly with internal weir cone, piping to ground, and flap valve
16- 3/4" Anchor Bolts
1- 24ft of 4" inlet riser piping
1- Deck perimeter guardrail - OSHA - HDG posts & toeboard with two aluminum handrails (CST std. construction)
1- Bolted outside ladder with safety cage, lockable hoop entry and safety swing gate for deck access - OSHA - HDG (CST std. construction)

PART 3 EXECUTION

3.01 TANK INSTALLATION

A. Install tanks in accordance with shop drawings, manufacturer's recommendations.

B. Particular care will be taken to protect the baked-on powdered coated panels from damage (i.e., scratches, abrasion) during field installation.

3.02 FIELD TESTING

A. Following completion of erecting and cleaning the tank, the structure shall be tested for liquid tightness by filling the tank to its overflow elevation

B. The contractor is accordance with the manufacturer’s recommendations shall correct any leaks disclosed by this test.

C. The owner shall furnish water required for testing at the time of tank erection completion, and at no charge to the tank erector.

END OF SECTION

SECTION 33 92 19

PRECAST CONCRETE MANHOLES/VAULTS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Precast vault sections, jointing materials, bases, tops, connections, and appurtenances for the leachate control system and stormwater system.

1.2 SUBMITTALS

A. Submit shop drawings of precast vault and manhole sections, jointing materials, bases, tops, and appurtenances for the leachate system and stormwater system.

PART 2 PRODUCTS

2.1 MATERIALS

A. Precast Concrete Vaults

1. Vault and Manhole Base: Precast concrete, complying with ASTM C478 standard specifications for Precast Reinforced Concrete Manhole sections. Bottom sections of manholes shall be monolithic with manhole base.

2. Joints: Gasketed and damp-proofed on exterior.

3. Pipe Connections: Core and boot seals and epoxy grout.

4. Epoxy coating on interior of manholes.

B. Access Lid: Type and Size per Drawings.

C. Mortar: Three parts masonry sand and one part Portland Cement by volume.

D. Epoxy Coating: Coal tar epoxy protective coating designed for immersion, interior or exterior corrosion resistance. Epoxy coating to be applied by the manufacturer.

E. Rubber Gaskets: ASTM C 443 Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.

F. Flexible Plastic Gaskets: Type B AASHTO M 198 Specification for Joints for Circular Concrete Sewer and Culvert Pipe Using Flexible Watertight Gaskets, Type B Flexible Plastic Gaskets.

PART 3 EXECUTION

3.1 INSTALLATION

A. Pipe Connection: Provide core-n-seal boots, link seals, or smooth, watertight connection of mortar around pipe where indicated on the drawings.

B. Install in accordance with manufacturer’s recommendations to line and grade shown on the Drawings.

C. Backfill in accordance with Section 31 00 00.

END OF SECTION

SECTION 40 05 12

DUCTILE IRON PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Detailed requirements for various ductile iron piping products. Some products specified in this Section may not be required for this Contract. Refer to the Drawings and Part VII - Water Mains and Service Laterals section outlined in the City of Madison Standard Specifications for Public Works Construction, 2017 Edition, or latest edition to determine particular ductile iron piping products to be provided under this Contract.

1.2 REFERENCE STANDARDS

A. American Water Works Association:
   1. AWWA A21.51, latest revision.

B. American National Standard
   1. ANSI C151, C111, latest revision

1.3 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Conform to the requirements specified herein for the type and class of material named. The Engineer reserves the right to reject any materials not meeting these Specifications as being defective.

B. Inspection: Accept piping and appurtenances on-Site in manufacturer's original packaging and inspect for damage.

C. Store materials according to manufacturer instructions.

D. Do not drop or bump materials against the ground.

PART 2 PRODUCTS

2.1 Pipe

A. Liquid Pipe: AWWA C151/A21.51, ductile iron.

B. Pipe Requirements
   1. Class 52 ductile iron
   2. Cement lined
   3. Push-on joint

4. Furnished with all necessary accessories
5. Bonding strap to provide electrical conductivity

C. Gaskets
   1. Gaskets shall conform to the requirements of ANSI/AWWA C111/A21.11
   2. Gasket Requirements:
      a. Plain rubber gaskets
      b. Retrained-join locking gaskets
         i. Use restrained joint locking gaskets when electing to *or* are otherwise required to meet thrust-restraint requirements by means of restrained-joint pipe.
         ii. Restrained-joint locking gaskets must be certified as compliant for use with the furnished pipe material by the pipe manufacturer.
   3. Nitrile or Fluorocarbon gaskets may be required if water mains are near contaminated soils.

D. Polyethylene Encasement
   1. Polyethylene encasement materials shall conform to the requirements of the American National Standard for Polyethylene Encasement for Ductile Iron Pipe Systems (ANSI/AWWA C105/A21.5 - latest revision).
   2. Polyethylene Encasement Requirements:
      a. 8-mil thickness (minimum)
      b. Furnish in either tube or sheet form

E. Fittings and Accessories:
   1. Mechanical Joint Fittings:
      a. Mechanical joint fittings are to conform to the requirements of American National Standard for Ductile Iron and Gray Iron Fittings, 3-inch through 48-inch, for Water (ANSI/AWWA C110/A21.10 - latest revision).
      b. Mechanical Joint Fitting Requirements:
         i. Class 250 mechanical joint pipe fittings.
         ii. Cement lined
         iii. All bells
         iv. Entire fitting tarred
         v. Conductive mechanical joint (no lead)
         vi. Furnish all necessary accessories (rubber gaskets, flanges, bolts, etc.)
   2. Mechanical Joint Restraints
         i. EBAA Iron Inc. - MEGALUG® Series 1100, or approved equal.
   3. Nuts and Bolts:
      a. Comply with AWWA C111/A21.11. - latest revision.
      b. Ensure that bolts are of sufficient length such that a minimum of ½-inch of threads are exposed beyond the end of the nut when tightened.
      c. Refer to the following table for the numbers, diameters, and lengths of bolts to be used:

Pipe Diameter (inches)	**No. of Bolts Required**	**Bolt Diameter (inches)**	**Bolt Length (inches)**	**Bolt Length for MEGALUG® (inches)**
4	4	3/4	3-1/2	4
6	6	3/4	3-1/2	4

4. Solid Sleeves:
    a. Class 52 ductile iron.

F. Services and Stops and Accessories.
    1. Service Laterals – 4 inch diameter
        a. Class 52 ductile iron in accordance with Section 2.1 A&B

G. Corporation Stops and Service Fittings.
    1. Curb Boxes
        a. Ensure that all curb boxes are complete, with covers marked "WATER."
        b. Curb Box Assemblies shall include the following:
            i. Brass screws.
            ii. 2½-inch new style flush fit cover.
            iii. 54-inch rods and guide rings.
            iv. 2½-inch screw type shaft.
            v. 37-inch bottom section.
            vi. 29-inch top section.
            vii. 16-inch center section.

H. Disinfection Commercials – NOT USED

I. Hydrants:
    1. Hydrants are required to have "breakaway" capability
    2. Acceptable models include:
        i. AFC Waterous, Model Pacer WB-67
        ii. Mueller, Model Super Centurion A423
    3. Nozzle Requirements
        i. Side nozzles: Two at 2½-inch diameter.
        j. Pumper nozzle: One at 4½-inch diameter.
        k. National Standard threads.
        l. Chains attaching the caps to the hydrant.
        m. Embossed with the word OPEN and an arrow showing that the hydrant opens left.
        n. Valve opening: 5¼-inch with National Standard operating nut shape.
        o. Painted red with blue nozzle caps – Waterous color M4152 (Houston Blue), or equal. 8. 360-degree top rotation.
        p. "Dry top" operating threads to be sealed when open.
        q. 6-inch mechanical joint bottom connection with conductive mechanical joint (no lead) gasket and necessary accessories.
    4. Upper valve plate requirements:
        a. Brass with a brass-to-brass foot valve.
    5. Drain valve facing requirements:
        a. Furnish hydrant with plastic drain valve facing (otherwise, drain tube/drain valve assembly).
    6. Operating nut requirements:
        a. One-piece operating nut.
    7. Reflective locating device:
        a. "Hydra-Finder" manufactured by RoDon Corp.
    8. Extensions: Per manufacturer's recommendations.

PART 3 EXECUTION

3.1 INSTALLATION

A. Construct water main and appurtenances in accordance with AWWA C600, latest revisions, except when otherwise required in these specifications.

B. Construct water mains and appurtenances in open trenches and in a manner to protect the pipe and appurtenances from unusual stresses at all times.

C. In accordance with trenching, Backfilling of Utilities Section 31 23 33.

D. Bell Holes:
1. Provide holes for pipe bells at each joint
2. Holes should be no larger than necessary for joint assembly, including installing the required overlaps for polyethylene encasement, and assurance that the pipe will lay flat within the trench.

E. Thrust Restraint:
1. Provide thrust restraint for all fittings by one of two methods:
   i. A combination of concrete thrust blocking and mechanical joint restraint.
   ii. A combination of push-on restrained joint pipe, and mechanical joint restraint.
2. Regardless of the restraint method employed, restrain all mechanical joints using MEGALUG® Series 1100 or approved equal retainer glands installed per the manufacturer recommendations and additionally include concrete blocking at all hydrant installations, cut-in connections, branch tee connections and live-tap connections, per Standard Detail Drawing 7.13 of the City of Madison Standards.
3. Concrete Thrust Blocking:
   i. Where concrete blocking serves as the thrust restraint method, block all hydrants and fittings, except vertical down bends, per the required bearing area in the table below and Standard Detail Drawing 7.13. Block vertical down bends per Standard Detail Drawing 7.14. Restrain per Standard Detail Drawing 7.15 of the City of Madison Standards only where specified or approved by the Engineer.

Required Undisturbed Bearing Area of Concrete Thrust Blocking (Square Feet)					
Fitting Size(In)	**Tee, Wye, Hydrant, Plug or Cap**	**90º Horizontal Bend, Plugged Cross or Tee (Plugged on Run)**	**45º Horizontal Bend**	**22-1/2º Horizontal Bend**	**11-1/4º Horizontal Bend**
4	0.9	1.3	0.7	0.4	0.2
6	2.1	3.0	1.6	0.8	0.4

Note: Listed areas are based on a test pressure of 150 psi and an allowable soil bearing pressure of 3,000 pounds per square foot. To compute bearing areas for different test pressure, use the following equation: Bearing area = (Test Pressure ÷ 150) x (Table Value)

4. Concrete thrust blocking must be at least two-feet thick over the entire bearing area.
5. On hydrants and fittings requiring less than 4-square feet bearing area use either cast-in place concrete or solid concrete blocks placed between the appurtenance and the undisturbed wall of the trench. Fill all voids with compacted clear stone or screenings.
6. For fittings requiring 4-square feet bearing area or greater, use only cast-in-place concrete meeting the requirements of Article 301 of City of Madison Standards and a minimum

strength of 3,000 psi at 7-days. Protect the concrete from freezing for a minimum of 24-hours after placement.

7. Do not perform pressure testing within 72-hours of pouring the thrust block. A 9-bag concrete mix may be authorized by the Engineer upon request.
8. Do not extend the concrete blocking beyond the joint. Protect all nuts and bolts from the concrete during pouring so they can be removed without damaging the thrust block.
9. Do not backfill over thrust restraint blocking until it has been inspected by the Engineer.

F. Joint Restraint

1. Where joint serves as a thrust restraint method, with the exception of vertical bends, restrain all push-on joints within the lengths specified in the 'Required Joint Restraint Distance from Fitting' table below. Restrain vertical bends per Standard Detail Drawing 7.16 of the City of Madison Standards.
2. Restrain push-on joints with the pipe manufacturer's approved joint restraint locking gasket per Article 702 of the City of Madison Standards.
3. Restrain all mechanical joints per Article 702 and Article 703 – 'Mechanical Joint Pipe and Fittings' of the City of Madison Standards.

REQUIRED JOINT RESTRAINT DISTANCE FROM FITTING (FEET)

FITTING TYPE	4-IN	6-IN	8-IN	10-IN	12-IN	16-IN	20-IN	24-IN
TEE: RUN OR CROSS:	10	10	10	10	10	20	20	20
TEE: BRANCH	10	10	10	10	10	10	10	10
CAP/PLUG ON DEAD END	30	45	60	70	80	110	140	160
90° HORIZONTAL BEND	10	15	20	25	25	30	40	50
45° HORIZONTAL BEND	5	10	10	10	15	15	20	25
22.5° HORIZONTAL BEND	5	5	5	5	10	10	10	15
11.25° HORIZONTAL BEND	3	3	3	3	5	5	5	5
REDUCER: SIZE x 4"	-	25	45	60	75	100	130	150
REDUCER: SIZE x 6"	-	-	25	45	60	90	120	145
HYDRANT	RESTRAIN ALL JOINTS ON HYDRANT LEAD							

NOTES:
SOIL TYPE = GM (SILTY GRAVELS & GRAVEL/SILT/SAND MIXES) DEPTH OF BURY = 6-FT
SAFETY FACTOR = 1.5 TRENCH TYPE = 4 TEST PRESSURE = 150 PSI

G. Installation Standards: Install Work according to applicable City of Madison Standards and Details.

3.2 FIELD QUALITY CONTROL

A. Inspect for damage to pipe lining or coating, and for other defects that may be detrimental as determined by the Architect/Engineer. Repair damaged piping, or provide new, undamaged pipe.

B. After installation, inspect for proper supports and interferences.

C. Testing:

1. Perform Hydrostatic pressure test and Conductivity test on piping according to City of Madison standards. No disinfection required.

3.3 CLEANING

A. Keep pipe interior clean as installation progresses.

B. Clean pipe interior of soil, grit, loose mortar, and other debris after pipe installation.

END OF SECTION

SECTION 40 05 33

HIGH-DENSITY POLYETHYLENE (HDPE) PIPE

PART 1 - GENERAL

1.1 Section Includes

A. HDPE Pipe and Fittings

1.2 Submittals

A. Submit Shop Drawings and Material Certification for all materials are supplied by the CONTRACTOR

PART 2 - PRODUCTS

2.1 Acceptable Manufacturers

A. HDPE Pipe/Manholes:

1. Plexco
   3240 N. Mannheim Road
   Franklin Park, Illinois 60131

2. Poly Pipe Industries, Inc.
   Drawer HH
   Gainesville, Texas 76240

3. Phillips Driscopipe, Inc.
   2929 North Central Expressway
   Richardson, Texas 75083

B. Valves:

1. ASAHI/AMERICA
   425 Riverside A venue
   Medford, Massachusetts 02155

C. Substitutions under provisions Section 01 00 00

2.2 Singe Walled HDPE Materials

A. All HDPE Pipe and fittings as shown on Drawings: Smooth wall pipe made from an HDPE material having a minimum designation code of PE 4710. The material shall meet the requirements of ASTM D 3350, and shall have a minimum cell classification of PE445474C. Sizes per Drawings.

B. Joints: heat fusion process (ASTM D3261) as per manufacturer instruction. In inaccessible areas, electro fusion joints will be allowed on a case by case basis. Mechanical joints are acceptable at manhole inlets of differing material. No branch saddle connections unless approved by OWNER. Use full size tees / crosses with reducers.

C. Bends shall be molded. Pre-fabricated fittings must be specifically approved by the ENGINEER.

2.3 Dual Containment HDPE Pipe

A. All HDPE Pipe, centralizers and fittings as shown on Drawings: Smooth wall pipe made from an HDPE material having a minimum designation code of PE 4710. The material shall meet the requirements of ASTM D 3350, and shall have a minimum cell classification of PE445474C. Sizes per Drawings.

B. All joints shall be heat fusion welded, except in inaccessible areas where electrofusion joints will be allowed on a case by case basis if requested by the Contractor. Mechanical joints are acceptable at manhole inlets of differing material. No branch saddle connections unless approved by OWNER. Use full size tees / crosses with reducers.

C. Centralizers welded to carrier pipe shall support carrier pipe within containment pipe. Centralizer support spacing and other pipe system requirements shall be in accordance with the Drawings.

D. End termination fittings shall be used to seal piping system at ends other than manholes. Fitting shall be simultaneously butt fused to carrier and containment pipe to seal the annular space. No other closure or termination will be allowed. This fitting shall also provide transition to single wall piping.

2.4 PVC Materials

A. Non-perforated and perforated PVC pipe and fittings as shown on drawings: ASTM D1785, Type I, Grade 1, Schedule 80, complete with required couplings, molded fittings, and well screen size, sizes per drawings.

B. Joints: Per Drawings. Solvent welds per ASTM D2855. Vanstone flanges for connections to HDPE.

C. Solvents: ASTM D2564, heavy-bodied solvent cement.

2.5 Valves

A. Gate Valves:

1. Corrosion-resistant thermoplastic gate valve rated for 150 psi compatible with HDPE and PVC pipe.
2. EPDM seals.

B. Check Valves:

1. Corrosion-resistant thermoplastic ball check valve rated for 150 psi compatible with HDPE and PVC pipe.
2. EPDM seats and seals.

C. Butterfly Valves:

1. Corrosion-resistant thermoplastic butterfly valve rated for 150 psi compatible with HDPE and PVC pipe.

2. Nitrile seats and seals.

D. Ball Valves:

1. Corrosion-resistant thermoplastic ball valve rated for 150 psi compatible with HDPE and PVC pipe.

2. Teflon® seats with EPDM backing cushions and EPDM seals.

2.6 Hardware

A. Hardware (bolts, flanges, back-up rings, etc.) used for flanges / mechanical joints shall be 316 stainless steel where buried in waste. Bolts shall be anti-seize type. Galvanized, zinc-plated bolts shall be used above grade or where outside the limits of waste. Ductile iron back-up rings shall be used above grade or where outside the limits of waste.

PART 3 - EXECUTION

3.1 Inspection

A. Inspect pipe, fittings, and other appurtenances before installation to verify quality of material.

B. Bends to be molded or prefabricated. Field fabricated fittings not allowed unless specifically approved by OWNER.

3.2 Preparation

A. Ream pipe and tube ends. Remove burrs.

B. Remove dirt and foreign material, inside and outside, from pipe and fitting materials before assembly.

C. Make straight field cuts without chipping or cracking pipe.

D. Seal pipe ends to keep clean during construction breaks overnight.

3.3 Installation

A. Make PVC solvent cement joints in accordance with ASTM D2855 and PPI-TR10.

B. Install PVC pipe and fittings to the line and grade specified on the drawings with bell end upstream.

C. Make HDPE butt fusion welds in accordance with manufacturers recommended procedures.

D. Install manholes, pipe, and fittings to the line and grade specified on the drawings, in accordance with manufacturer's recommendations.

E. Lay pipe from the low end toward the high point. Provide continuous smooth invert. Cut in and connect to existing pipe as required. Consult with OWNER if adjustments to inverts are required at connections to existing pipe. Tape or otherwise seal open pipe ends when handling on site to minimize potential for debris to collect in pipe.

F. The maximum allowable tolerance for grade is 0.05 foot.

G. Construct bedding material and specified Backfill Materials over pipe with care, to avoid damage to pipe. Minimize traffic and turning of traffic over pipe.

3.4 Mechanical Connections

A. Mechanical Connections shall consist of the following unless otherwise noted:

B. HDPE Flanged Connections shall be butt-fused to HDPE pipe. Outside diameter and drillings shall comply with ANSI B16.1. Back-up flanges shall be ductile iron and comply with ANSI B16.6 unless otherwise specified.

3.5 Field Quality Control

A. Allow ENGINEER to observe pipe alignment and joints prior to backfilling.

B. Maximum allowable depth of cuts, gouges, or scratches on the exterior surface of pipe or fittings shall be limited to 10% of the wall thickness. Interior of the pipe shall be free of cuts, gouges, and scratches.

C. Jet clean pipe with water using sewer cleaning equipment when construction is completed, prior to final acceptance.

D. Pressure testing: Commence test procedures when the following conditions have been met:

1. Pipe section to be tested is clean and free of dirt, sand or other foreign material.
2. Plug pipe outlets with test plugs. Brace each plug securely to prevent blowouts. Use concrete if necessary.
3. Add compressed air slowly.
4. Pressurizing equipment shall be continuously monitored and include a regulator set to avoid over-pressurizing and damaging an otherwise acceptable section of pipe.
5. Provide necessary pipe connections between the section of line being tested and the compressed air supply, together with test pressure equipment, meters, pressure gauge, and other equipment, materials, and facilities necessary to perform the specified tests.
6. Furnish and install bulkheads, flanges, valves, bracing, blocking or other temporary sectionalizing devices that may be required.
7. Remove temporary sectionalizing devices after tests have been completed.

E. Testing Equipment

1. Contractor shall provide all equipment required for this testing procedure.
2. Testing Equipment shall include, but may not be limited to:
   a. Polyethylene flange adapter with steel blind flange.
   b. Temperature gauge (0ºC to 100ºC) tapped and threaded into blind flange.
   c. Pressure gauge (0 to 200 psi) ASME Standard B40.1 Grade 2A (accuracy of ±0.5% of full scale) with minor graduation marks no greater than 1 psi.
   d. Inlet valve to facilitate compressed air hose.
   e. Ball valve to release pipe pressure at test completion.
   f. Polyethylene reducers to be used to adapt test flange to size of pipe being tested.
   g. Air compressor shall provide adequate air supply for testing.

h. Pressurizing equipment shall include a regulator set to avoid over-pressurizing and damaging otherwise acceptable pipe.

3. Provide verification and results of gauge calibration prior to test.

F. Testing

1. Owner and Engineer shall be given 48-hr notification prior to test.

2. Appropriate Safety precautions must be in-place.

3. Pipe Test Segments:

a. Butt-fusion weld pipe segments.

b. Less than 2000 feet in length.

c. Blind flange with test apparatus on one end and fused cap or blind flange assembly on opposite end.

4. Environment:

a. Bury test segment or lay test segment on ground surface and allow it to reach ambient temperature before test.

b. Perform test during period when pipe segment will be out of direct sunlight and not subject to heating or cooling, to minimize pressure changes as a result of temperature fluctuations.

5. Test (observed by Engineer):

a. Apply test pressure of 10 psi or 1.1 times operating pressure, whichever is greater, to test segment.

b. Observe test pressure for 1-hour.

c. Mathematically correct pressure drop for temperature change.

d. Temperature corrected pressure drop over 1-hour period should not exceed 1%.

6. Test Failure

a. If retest is necessary, allow pressure to relax to 0 psig for at least 8 hours prior to retest.

b. Perform the following when pipe segment fails test.

i. Check entire length of pipe and fusion welds for cracks, pinholes, valves leaks, perforations or other possible leakage points.

ii. Check blocked risers and capped ends for leakage and check gaskets at blind flanges.

iii. Verify leaks by applying a soapy water solution and observe for bubble formation.

iv. Repair pipe and fused joint leaks by cutting out leak areas and refusing suitable segments.

v. After the leaks are repaired, retest the pipe after the 8 hour relaxation period.

7. Test Reporting

a. Each test shall be reported in writing, on Attachment 1 included with this section.

b. Include following information if failure occurs:

   i. Location of failure segment.

   ii. Nature of leaks.

   iii. Details of repairs performed.

   iv. Retest results

G. Dual Contained Pressure and Leakage Testing

1. General: Carrier and containment pipe shall be subjected to the following testing. Testing shall be the responsibility of Contractor.

2. Pressure Test: After pipe has been installed, fusion completed, and trench partially backfilled (leaving joints exposed for examination), carrier pipe shall be filled with water in a manner to expel all air. Pipeline shall be subjected to a test pressure of 1.5 times the system operating pressure for a period of a least 1 hour. Add and measure the amount of make-up water required to return to the test pressure and compare this with the maximum allowances stated in Underground Installation of Polyolefin Piping as published by the Plastics Pipe Institute.

3. Containment Pipe Testing: Carrier pipe shall be brought up to and held at system test pressure while containment pipe is leak tested. Based on the lowest pressure rated fitting or component in system, air pressure of no higher than 10 psi shall be used. Do not over pressurize annular space. Pipe shall be brought up to test pressure and held for 10 minutes or until the pressure stabilizes. Test shall begin when the pressure stabilizes and lasts for 10 minutes. If no significant pressure drop is noted, the pipe has passed the test.

4. Retesting: If deficiencies are revealed during tests, such deficiencies shall be corrected. Tests shall be reconducted until the results of tests are within specified allowances with no additional cost to Owner.

5. Visual Test: All exposed joints, fittings, and valves shall be examined for leaks. Visible leaks shall be stopped and/or the defective pipe, fitting, joint, or valve shall be replaced.

ATTACHMENT 1 TO SECTION 33 91 00
FORM
HDPE PIPE PRESSURE TEST REPORT

Project Name/No.: ______________________________ Date: ________________

Contractor: ______________________________ Time: ________________

Person Performing Tests: ______________________________

Description/Location of Test Segment: (Pipe Diameter, Length, and SDR's)

____

____

Location of Pipe Test Segment

Station From: Station To:

T_i = Initial Temperature = ____________ °F

P_i = Initial test pressure = ____________ psi

P_c = Initial Pressure in mb corrected for temperature (T_t) at time "t"

t = Time in minutes from initiation of test

T_t = Temperature in °F at time 't'

P_t = Test pressure in psi at time 't'

$$P_c = \frac{(P_i + 14.7)\,(T_t + 459.67)}{(T_i + 459.67)} - 14.7$$

$$\text{Percent Pressure Drop} = \frac{P_c - P_t}{P_c} \times 100$$

Time (min)	T_t Temp Reading (°F)	P_t Gauge Pressure (psi)	P_c Corrected Pressure (psi)	Pressure Drop (%)
0				
20				
30				
40				
50				
60				

Pass/Fail: ________________ Retest (yes/no) ________________

Description/Nature of leaks repair of retest segment:

____

____

____

END OF SECTION

DIVISION – ANR PIPELINE COMPANY STANDARDS AND SPECIFICATIONS

TED-1930-VEL Natural Gas Velocity Limits Through Measurement and Pipeline Facilities (US-MEX)

TransCanada
In business to deliver

Item ID: 004485636	Rev.: 01	Status: Issued	Effective Date: 2013-MAY-01

Approvals

Originator: Alan Anderson, P.L. (Eng) Design Engineering Support	Alan Anderson Signature	May 2 - 2013 Date
Discipline Checker One: Gerard Lalonde, P. Eng. Design Engineering Support	G Lalonde Signature	May/14/13 Date
Responsible Engineer/Approver Landy Ramirez, P. Eng. Design Engineering Support	Landy Ramirez Signature	5-13-2013 Date
Management Endorsement: Pat Jackson, Manager Design Engineering Support	Pat J Signature	May 14, 2013 Date

SUMMARY

This document provides velocity criteria for the design of pipeline and measurement facilities.

DOCUMENT HISTORY

Revision Log			
Rev. No.	**Brief Description of Change**	**Responsible Engineer**	**Effective Date**
03			
02			
01	• This Directive has been updated as part of the Continuous Improvement Plan for Engineering Standards. • This document conforms to the new template. • References in Section 3.1 have been revised and changed from IGE to IGEM*.	Landy Ramirez	2013-MAY-01
00	• This a new document. Modified for conversion from Canadian to US Standard	Curtis Parker	2001-SEP-08

***In 2001, the Institution of Gas Engineers (IGE) became the Institution of Gas Engineers and Managers (IGEM).

Table of Contents

List of Tables

DEFINITIONS

Terms	Definition
API	American Petroleum Institute
IGEM	Institution of Gas Engineers and Management
ft/s	feet per second
NPS	nominal pipe size

1 PURPOSE

The purpose of this Directive is to provide guidelines for adequate design and sizing of pipeline and measurement facilities. These guidelines will provide for cost effective compression, operation and maintenance and prevent the need for flow restrictions and frequent inspections.

2 SCOPE

This Directive applies to Internal Engineering Standards used in all divisions of TransCanada Pipelines Limited (TransCanada) and its wholly-owned subsidiaries, and all operated entities in the United States and Mexico.

3 REFERENCES

3.1 Regulations, Codes and Standards

3.1.1 All design shall be governed by the latest edition of the following codes and standards:

IGEM/TD/1 *Steel Pipelines and Associated Installations for High Pressure Gas Transmission*

IGEM/TD/13 *Pressure regulating installations for Natural Gas, Liquefied Petroleum Gas and Liquefied Petroleum Gas/Air*

API RP 14E *Design and Installation of Offshore Production Platform Piping Systems*

3.2 Internal References

Macleod, John. *Maximum Gas Velocity Guidelines for Compressor, Meter and Control Valve Stations*, Nova Gas Transmission Ltd., March 3, 1993.

4 POLICY

The following velocity limits that TransCanada will apply to its measurement and pipeline facilities are based on the requirements in Section 5.

- For initial design of new facilities, the piping velocity limit will be 50 ft/s.
- For the design of additions and flow increases to existing facilities, the piping velocity limit will be 70 ft/s.
- For flow increases to existing facilities (or situations when increased flow is required on a short-term basis due to system restrictions, which result in velocities over 70 ft/s), increased velocities may be allowed on an exception basis after analysis of the existing facilities and layout.

5 BACKGROUND

5.1 Gas Velocity Limit Based on Economics

The design of the piping facilities from an economic standpoint, results in optimization of the pressure drop (i.e., any added energy cost must be paid for). Hence, the balance between capital and operating expenditure must be economic and analyzed in detail at the design stage. The factors usually considered are the following:

- material cost,
- labour cost,
- operating cost,
- borrowing cost, and
- present and future operating modes.

The API RP 14E standard is not directly applicable to TransCanada but typical for the industry. It outlines acceptable pressure drops over a range of operating pressures and is displayed graphically as maximum gas velocity versus pipe size (e.g., for a pipe size of NPS 20, P = 500 psig; the acceptable velocity is 59 ft/s or for P range from 101 psig to 500 psig; the acceptable pressure drop is 0.20 to 0.49 psig/100 ft of pipe.

NOTE: This criteria cannot be directly used for situations where the pressure drop is not of economic concern, for example, at sales stations where gas pressure is reduced from the TransCanada mainline to the customer maximum allowable operating pressure through control valves. Because TransCanada’s measurement facilities are subject to frequent increases in volume throughput, it would not be a prudent practice to initially design facilities to the maximum velocity limits.

5.2 Velocity Limit Based on Erosion

The limitation defined by unacceptable rates of erosion represents absolute boundaries to safe piping facility operation and must not be exceeded. This type of velocity limit applies to all elements of the pipeline system and must be evaluated for all designs.

Failure can occur when solid/liquid particles carried with the gas impinge on the piping at elbows, reducers, tees, orifices, valves and other piping discontinuities where changes in flow direction occur. The API RP 14E standard applies to a two phase flow:

The following British technical standards are recommendations for gas transmission and distribution practice, which include maximum gas velocities that pertain to the erosion:

- IGEM/TD/1 *Steel Pipelines and Associated Installations for High Pressure Gas Transmission*
- IGEM/TD/13 *Pressure regulating installations for Natural Gas, Liquefied Petroleum Gas and Liquefied Petroleum Gas/Air*

NOTE: For erosional velocity, refer to API RP 14E, Equation 2.14, Section 2.5 a. (1).

Summarizing the above two British recommendations, the following statements apply:

- Gas which is dry but may have dust should have a maximum gas velocity of 70 ft/s.
- Gas in regulating stations (and similar) should have velocities limited to 130 ft/s on the downstream side of filters.

5.3 Gas Velocity Limit Based on Indirectly Defined Damage

In contrast to the two previous gas velocity limits, this limit requires specialized and detailed analysis of the particular piping configuration. In addition, the analysis results do not directly address the velocity limits. Instead, solutions to the predicted problems are developed based on other guidelines (pulsation, noise, vibration and metering errors), which have a direct effect on gas velocities.

Control valve sizing is an example where noise guidelines are considered. At no time is the sonic flow recommended through the valve, rather a pressure drop cascade should be used. Otherwise, acoustic fatigue damage is likely to occur.

Destructive vibration of the piping may result when vortex shedding at a tee (dependent on gas velocity) produces local acoustic and structural resonance.

NOTE: The API RP14 E standard (as an alternative to the detailed studies) suggests a maximum gas velocity of 59 ft/s to reduce the potential for noise-related problems.

6 VALUE ANALYSIS / COST BENEFIT

For TransCanada facilities, the economics are determined by the system design. Because the economics of pressure loss favor low velocities, erosion and other velocity limitations discussed are rarely a concern.

For station piping, the API RP 14E standard establishes acceptable pressure drops for a range of pressures. The pressure drops listed in Table 6-1 were developed from experience by the API (American Petroleum Institute) and have been found to be an acceptable balance between capital expenditures and operating costs.

Table 6-1: Acceptable Pressure Drops for Station Piping

Operating Pressure (psig)	Acceptable Pressure Drop (psig/100 ft)
0–100	0.05–0.19
101–500	0.20–0.49
501–2000	0.50–1.12

–END OF DOCUMENT –

PURPOSE

This Specification provides Company requirements for the qualification, manufacture, inspection, and testing of end closures.

SCOPE / APPLICABILITY

This Specification applies to NPS 2 and larger end closures to be used in the Company's non-sour natural gas and non-sour liquid hydrocarbon pipeline systems in Canada, the United States, and Mexico.

This Specification does not apply to the manufacture of blind flanges.

The Responsible Engineer shall be contacted for clarification if needed.

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1 GENERAL

All end closures shall conform to the following requirements:

- End closures shall meet the additional requirements in the request for proposal and the purchase order description, where applicable.
- The Manufacturer shall supply the Company, at the time of quotation, any exceptions or alternatives to the requirements outlined in this Specification. Items covered by technical agreements need not be addressed at the time of quotation as the technical agreements apply to each order.

2 DESIGN REQUIREMENTS

End closures shall be designed in accordance with the applicable requirements of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 except for the weld bevel. The weld bevel shall be designed in accordance with the requirements of CSA Standard Z662, ASME B31.3, ASME B31.4 or ASME B31.8.

Note: Where the material is “dual certified”, it shall be permissible to use the yield strength of the higher strength material in the design of the weld bevel.

The design features outlined in Table 2-1 are required for all end closures.

Table 2-1: End Closure Design Feature Requirements

Feature	Requirements
Safety-Locking Device	End closures shall be equipped with a safety-locking device that will prevent operation unless the pressure is relieved. The device shall be accessible and shall be located and constructed to ensure its operability.
Welding End Hub	• End closures NPS 4 or larger shall be supplied with a hinge or other type of handling device attached to the welding end hub. • The specified minimum yield strength (SMYS) of the welding end hub shall not be less than two-thirds of that of the matching pipe specified on the purchase order description, where applicable, and the request for proposal.[1,2]

Notes:

[1] The actual yield strength shall not be used in the above calculation unless it is equal to the specified minimum yield strength.

[2] Where the material is “dual certified”, this restriction shall apply to the material with the highest specified minimum yield strength.

2.1 End Closure Orientation

The Manufacturer shall have a design for end closures that are installed in the horizontal position as well as in the vertical position. The Company will specify the orientation on the purchase order description, where applicable, and the request for proposal.

For end closures that are to be installed in the horizontal position, the Manufacturer shall have a design for end closures that can be opened in the right direction as well as the left direction. Hinge pins shall be secured in place.

- "Opening direction right" means the door will swing to the right of an observer looking at the bore of the end closure from the door.
- "Opening direction left" means the door will swing to the left of an observer looking at the bore of the end closure from the door.

The Company will specify the opening direction on the purchase order description, where applicable, and the request for proposal.

2.2 Design Pressure

End closures shall be designed for a cold working pressure rating designated by the nominal pressure classes (PN) shown in Table 2-2 below.

Table 2-2: Cold Working Pressure Rating by Pressure Class

Nominal Pressure Class	Cold Working Pressure Rating, kPa (psi)
PN 100/ASME Class 600	10,200 (1480)
PN 150/ASME Class 900	15,300 (2220)

The required nominal pressure class is shown on the purchase order description, where applicable, and the request for proposal.

3 MATERIALS REQUIREMENTS

All materials shall be suitable for service at the minimum design metal temperature (MDMT) specified on the request for proposal and purchase order, and shall meet the requirements of this specification.

Unless otherwise specified on the purchase order description (where applicable) and the request for proposal, the seal materials shall be suitable for exposure to non-sour natural gas or non-sour liquid hydrocarbon containing by-products of processing and treatment of natural gas or liquid hydrocarbon respectively, whichever applies.

3.1 Materials for Bolting for Pressure-Containing Parts

Bolting used for pressure retention purposes shall be manufactured in accordance with the requirements of the ASME Boiler and Pressure Code, Section II, SA320, Grade L7 or L7M or L43; or SA194, Grade 4, 7, or 7M.

3.2 Materials for Pressure-Containing Parts Other Than Bolting

The following requirements apply to all pressure-containing parts other than bolting.

3.2.1 Acceptance of Materials

Cast components shall be made in accordance with an acknowledged international standard.

Materials selected for pressure-containing parts, other than bolting, shall be:

- in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section II
- submitted for review and written acceptance by the Company prior to manufacture

Note: It shall be acceptable to use "dual certified" materials; i.e., the material is certified to both an ASME SA specification and an ASTM A specification. An example of a "dual certified" material is SA 350 LF 2, Class 1/ASTM A 694 F48.

3.2.2 Heat Treatment of Test Specimens

Test specimens for mechanical tests shall be given the same heat treatment as the part they represent.

An exception is made for a part that has been tempered or stress-relieved. In this case, the part need not be retested for subsequent tempering or stress-relieving operations provided that the subsequent operations are performed at or below the temperature of the first operation.

3.2.3 Carbon Equivalent

For NPS 16 and larger end closures, the carbon equivalent (C.E.) shall be calculated for each heat of material to be used for field weld ends in accordance with the following equation and shall not exceed 0.45:

$$C.E. = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

The carbon equivalent shall be calculated using the results of either the heat analysis or a product analysis. Where the heat analysis does not include all of the elements in the carbon equivalent formula being used, a product analysis shall be conducted for all of the elements in the carbon equivalent formula being used.

3.3 Notch Toughness

All pressure-containing metallic shell components shall be Charpy V-notch tested in accordance with the requirements of ASTM A 370, except:

- bolting material 13 mm and less in diameter
- nuts of any size
- components manufactured from austenitic or duplex stainless steel
- end closures with a diameter less than NPS 16 and with a minimum design metal temperature of -29°C (-20°F) or higher where allowed by industry codes and standards, unless otherwise specified on the purchase order

3.3.1 Test Specimen and Results

Charpy V-notch tests shall be performed on the largest practical specimen size.

- The minimum average absorbed energy for any test shall be 18 J (13 ft·lb) for parts lower than Grade 359 (52 ksi), based on full-size speciments.

- The minimum average absorbed energy 27 J (20 ft·lb) for parts Grade 359 (52 ksi) or higher, based on full-size specimens.
- Where sub-size specimens must be used, the minimum energy absorption requirement shall be 18 J (13 ft·lb) or 27 J (20 ft·lb), whichever is applicable, multiplied by the ratio of the specimen width to 10 mm (0.394 in.).

3.3.2 Test Temperature

Charpy V-notch tests shall be performed at the specified minimum design metal temperature (MDMT) listed on the request for proposal and purchase order. Materials tested at lower temperatures shall be considered acceptable if the requirements of Section 3.3.1 of this specification are met at the lower test temperature.

4 PREPRODUCTION REQUIREMENTS

Prior to the commencement of production, the Manufacturer shall submit, or have previously submitted, to the Company the documents in Table 4-1 and shall have received written acceptance from the Company unless otherwise specified.

Table 4-1: Preproduction Documentation Requirements

Item	Requirements
Copy of quality program	Specific to quality program intended for the production of the ordered end closure; see Section 5.1
Copy of the quality program registration certificate	See Section 5.1
List of materials	Required for each pressure-containing part; see Section 3.2.1
Welding procedures	See Section 5.2
Definition of critical sections	Only required for pressure-containing castings; see Section 7.1.1
Drawings	Drawings shall include: • Outline dimensions • Weld end dimensions • Welding procedure numbers to be used for welds (see Section 5.2) • Bill of Materials for pressure-containing parts, including material designations • The Company materials number • The Company specification and revision date • The installation position of the end closure (See Section 2.1) • The opening direction, where applicable (See Section 2.1)

5 MANUFACTURING REQUIREMENTS

The following requirements apply to the manufacturer and manufacturing process.

5.1 Quality Program

The Manufacturer shall have and adhere to a documented quality program accepted in writing by the Company prior to production (e.g., ISO 9001, ASME BPVC Section VIII “U” Stamp).

5.2 Welding Qualification

Welding procedures for the following welds shall be submitted by the manufacturer or have been previously submitted for review and written acceptance by the Company prior to use:

- Type 1: Pressure-containing fabrication welds
- Type 2: Welds defined by the Company as critical
- Type 3: Weld repairs to the welds defined in type 1 and 2
- Type 4: Weld repairs to pressure-containing cast components that will be used on NPS 16 and larger end closures

Weld qualification requirements for these four weld types are outlined in Table 5-1.

Table 5-1: Weld Qualification Requirements

Requirements	Weld Type			
	1	2	3	4
Welds shall be made using welders and welding procedures qualified in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section IX or equivalent approved by the Company.	x	x	x	x
Welding procedure qualifications shall include CVN testing in the weld and heat-affected zone and the requirements of Section 3.3 shall be met.	x	x	x	x
Specimen quantity, location, and orientation shall be in accordance with the requirements of Paragraphs UG-84 (g) and UG-84 (h)(3) of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.	x	x	x	-

Welds not defined above shall be made using welders and welding procedures qualified in accordance with the requirements of the applicable material specification or ASME Boiler and Pressure Vessel Code, Section IX.

Where pressure-containing cast components are obtained from a sub vendor, the end closure manufacturer shall be responsible for obtaining the required weld repair procedures.

5.3 Plant Access

While work on the contract is being performed, the Company or its representative shall have free entry at all reasonable times to all parts of the Manufacturer’s facilities involved in the production of the end closures ordered. All reasonable facilities shall be provided to the Company or its representative to satisfy that the product is being furnished in accordance with this Specification.

6 PRESSURE AND OPERATIONAL TEST REQUIREMENTS

The complete end closure shall be capable of withstanding a pressure test at a pressure equivalent to 1.5 times the cold working pressure rating of the end closure. Pressure and operational testing by the Manufacturer is not mandatory.

7 INSPECTION REQUIREMENTS

All tests and inspections required by this specification shall be performed in the Manufacturer's plant prior to shipment. Tests and inspections shall be conducted to cause no undue interference with the operations of the Manufacturer's plant. The Company reserves the right to witness any test but it does not constitute a hold point unless explicitly identified.

7.1 Nondestructive Examination (NDE)

The following requirements apply to NDE of pressure-containing castings and welds, as well as reporting NDE results.

7.1.1 Pressure-Containing Castings

All pressure-containing castings for NPS 16 and larger end closures shall be fully inspected by magnetic particle examination in accordance with the requirements of MSS SP-53.

Critical sections of pressure-containing cast components shall be defined by the Manufacturer and accepted in writing by the Company.

Critical sections and weld repairs to critical sections of cast components used on NPS 16 and larger end closures shall be inspected by film radiography, in accordance with the requirements of MSS SP-54 or in accordance with a Company accepted ultrasonic inspection procedure.

7.1.2 Welds

Any NDE conducted must meet the requirements of the applicable paragraph or appendix of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 shown below:

- Radiographic inspection: Paragraph UW51.
- Ultrasonic inspection: Appendix 12.
- Magnetic particle inspection: Appendix 6.
- Liquid penetrant inspection: Appendix 8.

Table 7-1 outlines the acceptable NDE methods for use on different weld types.

Table 7-1: Acceptable NDE Method by Weld Type

Weld Type		Acceptable NDE Methods	
		Radiographic or Ultrasonic Inspection	Magnetic Particle or Liquid Penetrant Inspection
1	Pressure-containing fabrication welds.	✓	-
2	Welds defined by the Company as critical.	✓	-
3	Weld repairs to weld types 1 and 2.	✓	-
4	Major weld repairs to pressure containing parts on NPS 16 and larger end closures.	✓	-
5	Welds joining a component smaller than NPS 2 to a pressure-containing part.	-	✓
6	Welds joining a non-pressure-containing part to a pressure-containing part (e.g., lifting lugs).	-	✓
7	Field Welding ends on NPS 16 and larger end closures (inspected after final machining)	-	✓

7.1.3 Reporting

All radiographs for pressure-containing fabrication welds and for repairs to such welds shall be identified and shall be available for the Company's representative to view.

A written record of all NDE results required by Section 7.1 of this Specification shall be prepared and certified by the Manufacturer for submission to the Company in accordance with the requirements of Section 10 of this Specification.

8 DEFECT CRITERIA AND REPAIR OF DEFECTS

Pressure-containing components containing defects shall be addressed through one of the following approaches:

- The defect shall be removed, provided that the remaining wall thickness is within the limits specified in the applicable material Specification.
- The defect shall be removed and the component repaired by welding, provided that:
  - o the qualification of the welders and welding procedures is in accordance with the requirements of Section 5.2 of this Specification,
  - o the weld repair is made using a low hydrogen process, and
  - o the weld repair is inspected in accordance with the requirements of Section 7.1.
  - o All major weld repairs to pressure-containing components that will be used on NPS 16 and larger end closures shall be heat-treated.

- The component shall be rejected.

9 MARKING REQUIREMENTS

End closures shall be marked with the following information:

- Manufacturer's identification
- Size
- ASME Pressure Class; e.g., PN 100 (ASME 600) or PN 150 (ASME 900)
- Minimum design temperature in degrees Celsius or Fahrenheit
- The unique traceability number

Additional markings desired by the Manufacturer are not prohibited. However, information on interpreting these additional markings shall be provided to the Purchaser.

The traceability number shall be stamped on the end closure. Other information shall be stamped on the end closure or marked on one or more nameplates.

10 CERTIFICATION PACKAGE

The Manufacturer shall supply to the Company, prior to shipping the end closures, reports and test certificates correlated to the end closure serial number and the unique traceability number.

The reports and test certificates shall contain the following information:

- Certificate of compliance for each order item (a document that states "The product was manufactured, sampled, tested, and inspected as specified in TES-FITG-EC1, Revision X, Dated YYYY/MMM/DD; and the purchase order; and was found to have met such requirements.").
- Carbon equivalent of weld ends of NPS 16 and larger end closures.
- Mechanical and chemical test results for each pressure-containing part.
- Product analysis, where required by Section 3.2.3.
- Certificate of compliance for bolting for pressure-containing parts.
- Test records from pressure tests, where applicable.
- A written record of all NDE results required by Section 7.1 of this Specification shall be prepared and certified by the Manufacturer for submission to the Company. These records shall clearly identify the procedure number and revision level used for the examination.
- Purchase order number.
- A copy of the Company accepted drawing.
- Identification of the welding procedures and revision numbers used.

- A photocopy of the nameplate.

11 GLOSSARY

Terms and Definitions related to this Specification can be found in APPENDIX A.

12 REFERENCES

This document relies on a number of references to legislation (act, statutes, and regulations), certificates, and orders and may include directives, guidelines, standards, and codes to the extent they contain legally binding requirements for TransCanada.

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 12-1.

Table 12-1: External and Internal References

Document No.	Title
Legal Requirements	
NEB OPR SOR/99-294	National Energy Board Onshore Pipeline Regulations (NEB OPR)
49 CFR 192	Code of Federal Regulations, Title 49 Part 192, Transportation of Natural Gas and Other Gas by Pipeline: Minimum Federal Safety Standard
49 CFR 195	Code of Federal Regulations, Title 49 Part 195, Transportation of Hazardous Liquids by Pipeline: Minimum Federal Safety Standard
Various	Applicable Provincial Regulations for Provincially Regulated Systems
NOM-007-SECRE	Transporte de Gas Natural (Where applicable)
Industry Codes and Standards	
CSA Z662	Canadian Standards Association (CSA) Oil and Gas Pipeline Systems
ASME B31.3	American Society of Mechanical Engineers (ASME) Process Piping
ASME B31.4	Pipeline Transportation Systems for Liquids and Slurries
ASME B31.8	Gas Transmission and Distribution Piping Systems
ASME BPVC-II	ASME Boiler and Pressure Code, Section II, Materials
ASME BPVC-VIII	ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Rules for Construction of Pressure Vessels
ASME BPVC-IX	ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications
ASTM A370	American Society for Testing and Materials (ASTM) Standard Test Methods and Definitions for Mechanical Testing of Steel Products

Document No.	Title
MSS SP-53	Manufacturers Standardization Society (MSS) Quality Standard for Steel Castings and Forgings for Valves, Flanges, Fittings, and Other Piping Components - Magnetic Particle Examination Method
MSS SP-54	Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components - Radiographic Examination Method
ISO 9001	Quality management systems – Requirements
Internal References – Documents that Reference this Specification	
N/A	N/A
Internal References – Documents Referenced by this Specification	
N/A	N/A

13 DOCUMENT HISTORY

Rev.		
03	Description	Effective Date
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	Responsible Engineer
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Cindy Guan, P. Eng
	Impact Assessment Summary	Document Owner
	This specification was revised to streamline the documentation required for the Materials Engineering group and to make it more easily accessible to those who use it.	Cindy Guan, P. Eng

14 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A.
Industry Standards	
N/A	N/A.
General	
N/A	This Specification was updated and put into the new template.

15 APPROVALS

APPROVALS		
Originator: Derek Chen, P. Eng. Welding and Materials Engineering	Chen Xiande Signature	Oct. 28, 2016 Date
Reviewer: Sajjad Kazi, P.E. Welding and Materials Engineering	Kazi Signature	Oct 28, 2016 Date
Responsible Engineer: Cindy Guan, P. Eng. Welding and Materials Engineering	Guan Signature Oct 28, 2016 Date	PROFESSIONAL ENGINEER XINGSHENG (CINDY) GUAN Oct 28, 2016 APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, Manager Welding and Materials Engineering	Signature	Oct. 28, 2016 Date

APPENDIX A TERMS AND DEFINITIONS

Terms	Definitions
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Material
Bolting	Bolts, studs, cap screws, and nuts
Certificate of Compliance	A document that states that the product was manufactured, sampled, tested, and inspected in accordance with the applicable specification, the purchase order and was found to have met such requirements. Bolting and pressure containing parts smaller than NPS 2 shall be furnished with a certificate of compliance. Material test reports (MTR's) shall be supplied for components NPS 2 and larger.
CFR	Code of Federal Regulations
Company or Purchaser	TransCanada PipeLines Limited, its corporate affiliate, or its agent
CSA	Canadian Standards Association
Door	The separable part of the end closure
End closure	A fitting with a removable part or assembly, including its adapting and operating mechanism, which provides access to the bore when open, and terminates and seals the bore when closed. Blind flanges are excluded.
Heat treatment	One or more of the following methods: • Stress relieving • Normalizing • Normalizing and tempering • Quenching and tempering
Hub	The part of the end closure that is welded to the pipeline
ISO	International Organization for Standardization
Major Weld Repair	• A weld repair that is made to correct leakage. • When the depth of the cavity prepared for welding exceeds 20% of the actual wall thickness or 1 inch, whichever is smaller

Terms	Definitions
	• When the area of the cavity prepared for welding exceeds 10 sq. in.
Manufacturer or Vendor	Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.
Material Number	The number assigned to each item on a purchase order (also known as part number, catalogue number, SAP number or material master number).
MSS	Manufacturers Standardization Society
NEB	National Energy Board
NOM	Norma Oficial Mexicana
Purchase order	The purchasing document used to purchase the specified item(s)
Regulatory Authority	The national and/or local regulator having jurisdiction over the facility.
Technical Agreement	The document signed by the Company and the manufacturer, which states a mutual agreement on a technical matter.
Traceability Number	A number that will be marked on the specified item(s) to allow identification of each piece. It shall consist of the letters PO, the purchase order number, the purchase order line item number, and where applicable, a numerical suffix. The numerical suffix is only required when more than one piece is supplied for the same item number on the same purchase order.
Welding Procedure	The Welding Procedure Specification, Procedure Qualification Record, and all associated non-destructive and destructive test data

PURPOSE

This Specification provides Company requirements for the qualification, manufacture, inspection, and testing of carbon steel full encirclement reinforcing saddles used for the reinforcement of welded branch connections.

SCOPE / APPLICABILITY

This Specification applies to carbon steel full encirclement reinforcing saddles, Grade 241 and higher (specified minimum yield strength of 35,000 psi and higher), used for the reinforcement of welded branch connections on non-sour natural gas and non-sour liquid hydrocarbon pipelines in Canada, the United States, and Mexico.

This Specification applies to all sizes of full encirclement reinforcing saddles.

The Responsible Engineer shall be contacted for clarification if needed.

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1 REQUIREMENTS

All full encirclement reinforcing saddles shall meet the additional requirements in the material description on the request for proposal and in the purchase order description.

2 DESIGN REQUIREMENTS

The Company shall calculate and determine the required length, wall thickness, and grade of the saddle. This information will be shown in the material description on the request for proposal and in the purchase order description.

The available reinforcement shall be that provided by the saddle only. The use of pads or weld build-up to provide added reinforcement shall not be permitted.

The specified minimum yield strength (SYMS) of the saddle shall not be less than 241 MPa (35,000 psi).

The reinforcing saddle shall meet all the dimensional requirements shown in APPENDIX A.

2.1 Joining Straps

Saddles shall be supplied with two longitudinal joining straps 50 mm (2 inches) in width (+/- 5 mm or +/- 1/4 inch) and with a thickness equal to the saddle wall thickness. The length of the joining straps shall be two times "D", where D is defined in APPENDIX A. Straps shall be fabricated from the same material as the saddle.

2.2 Epoxy Injection

Drilled and tapped holes for epoxy injection to further support the branch connection shall be made for all hot tap reinforcing saddles with an outlet/branch connection of NPS 10 and larger, as shown in APPENDIX B. Plugs with recessed head shall be supplied and installed, as listed in APPENDIX B.

3 MATERIALS REQUIREMENTS

Saddles shall conform to the strength and chemical composition requirements, including carbon equivalent, of MSS SP-75 or CSA Z245.11.

3.1 Weldability

Materials used in the manufacture of saddles shall be suitable for field welding. When required by the Company, the manufacturer shall demonstrate the weldability of the material in accordance with the requirements of Appendix "X2", MSS SP-75.

3.2 Heat Treatment

Saddles shall be heat treated after manufacture in accordance with applicable industry standards and requirements.

Test specimens shall be in the same heat treated condition as the saddles supplied and the sampling method shall be submitted unless otherwise agreed by the Company.

3.3 Tensile Properties

Tensile tests, where required, shall be performed in accordance with the requirements of ASTM A370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products.

- Tensile tests shall be performed by the saddle manufacturer for each heat of material with SYMS 290 MPa (42,000 psi) and higher.
- Additional tensile tests are not required for material with SYMS less than 290 MPa (42,000 psi); provided that the properties reported in the material test certificates for the starting material meet the requirements of MSS SP-75 or CSA Z245.11.

Tensile test results, including yield strength, tensile strength, and elongation, shall conform to the requirements of MSS SP-75 or CSA Z245.11.

If the tensile test results fail to conform to the specified requirements, the manufacturer may elect to retest the material. The retest procedure, including the number of retests and the acceptability of the test results, shall be subject to written agreement between the Company and the Manufacturer.

4 PREPRODUCTION REQUIREMENTS

The Company will supply the Manufacturer with the following information in the material description on the request for proposal and in the purchase order description:

- The design conditions for which the saddles are intended
- The header pipe outside diameter, wall thickness, and grade
- The branch pipe outside diameter, wall thickness, and grade
- The minimum grade of the saddle
- The minimum saddle thickness
- The minimum length of full thickness reinforcement

Prior to the commencement of production, the Company acceptance of the following documents are required.

- Types and grades of materials used for the manufacturing of saddles
- Sequence of manufacturing operations
- Heat treatment procedures, if any
- For tensile tests, the test specimen sampling methods
- Nondestructive inspection procedures
- A copy of the quality program, unless the manufacturer is registered to ISO 9001 in which case a copy of the registration certificate is sufficient
- A copy of the drawings with the detailed dimensional and ordering information filled in

The manufacturer shall inform the Company in writing of any changes to the above documents and shall obtain the written acceptance of the Company for such changes.

5 MANUFACTURING REQUIREMENTS

The following requirements apply to the manufacturer and manufacturing process.

5.1 Quality Program

The manufacturer shall have and adhere to a documented quality program that is accepted in writing by the Company prior to production (e.g., ISO 9001).

5.2 Plant Access

While work on the contract is being performed, the Company or its representative shall have free entry at all reasonable times to all parts of the Manufacturer's facilities involved in the production of the saddles ordered. All reasonable facilities shall be provided to the Company or its representative to satisfy that the product is being furnished in accordance with this Specification.

6 OPERATIONAL TEST REQUIREMENTS

Operational testing in the plant is not mandatory.

7 INSPECTION REQUIREMENTS

All tests and inspections required by this specification shall be performed in the Manufacturer's plant prior to shipment. Tests and inspections shall be conducted to cause no undue interference with the operations of the Manufacturer's plant. The Company reserves the right to witness any test but it does not constitute a hold point unless explicitly identified.

7.1 Nondestructive Examination (NDE)

All nondestructive examination procedures shall be submitted for review and written acceptance by the Company prior to use.

The bevel of the branch outlet shall be inspected by a liquid penetrant or magnetic particle technique for defects. Acceptance criteria and repair requirements shall be as defined in:

- ASME Section VIII, Division 1, Appendix 6 for magnetic particle examination.
- ASME Section VIII, Division 1, Appendix 8 for liquid penetrant examination.

8 MARKING REQUIREMENTS

Saddles shall be die stamped with the following information:

- Size; i.e., NPS ____ (header) x NPS ____ (branch)
- Specified minimum yield strength of the saddle or CSA grade
- Starting material designation; e.g., ASTM A516 Grade 70

- Manufacturer's identification
- Heat number of the starting material
- Traceability number
- An identification number matching the two halves of an individual saddle and match marks indicating how the top and bottom sections are to be aligned

Saddles shall have the following information painted on the outside:

- Company purchase order number.
- Company project number.
- Company project name.

Saddles for inventory shall have the word “inventory” painted on the outside and do not require Company project number or Company project name to be painted on the outside.

Additional markings may be applied at the manufacturer's option.

9 CERTIFICATION PACKAGE

Prior to shipping the saddle, the manufacturer shall supply to the Company, two copies of the reports and test certificates that are correlated to the traceability and material numbers. The reports and test certificates shall be in a format acceptable to the Company.

The reports and test certificates shall contain the following information:

- Chemical composition
- Carbon equivalent
- Methods of heat treatment
- Tensile test results
- Nondestructive inspection results for tests performed in accordance with the requirements of Section 7.1
- Confirmation that the reinforcing saddles were manufactured in accordance with the requirements of this Specification

10 GLOSSARY

Terms and Definitions related to this Specification can be found in APPENDIX C.

11 REFERENCES

This document relies on a number of references to legislation (act, statutes, and regulations), certificates, and orders and may include directives, guidelines, standards, and codes to the extent they contain legally binding requirements for TransCanada.

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 11-1.

Table 11-1: External and Internal References

Document No.	Title
Legal Requirements	
NEB OPR SOR/99-294	National Energy Board Onshore Pipeline Regulations (NEB OPR)
49 CFR 192	Code of Federal Regulations, Title 49 Part 192, Transportation of Natural Gas and Other Gas by Pipeline: Minimum Federal Safety Standard
49 CFR 195	Code of Federal Regulations, Title 49 Part 195, Transportation of Hazardous Liquids by Pipeline: Minimum Federal Safety Standard
Various	Applicable Provincial Regulations for Provincially Regulated Systems
NOM-007-SECRE	Transporte de Gas Natural (Where applicable)
Industry Codes and Standards	
CSA Z662	Canadian Standards Association (CSA) Oil and Gas Pipeline Systems
CSA Z245.11	Steel Fittings
ASME B31.3	American Society of Mechanical Engineers (ASME) Process Piping
ASME B31.4	Pipeline Transportation Systems for Liquids and Slurries
ASME B31.8	Gas Transmission and Distribution Piping Systems
ASME BPVC-VIII	American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section VIII, Division 1, Rules for Construction of Pressure Vessels
ASTM A370	American Society for Testing and Materials (ASTM) Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A516	Specification for Pressure Vessel Plates, Carbon Steel, for Moderate and Lower Temperature Service
ISO 9001	Quality management systems – Requirements
MSS SP-75	Manufacturers Standardization Society (MSS) Specification for High Test Wrought Butt Welding Fittings
Internal References – Documents that Reference this Specification	
N/A	N/A
Internal References – Documents Referenced by this Specification	

Document No.	Title
N/A	N/A

12 DOCUMENT HISTORY

Rev.		
05	Description	Effective Date
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	Responsible Engineer
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Derek Chen, P. Eng.
	Impact Assessment Summary	Document Owner
	This specification was revised to streamline the documentation required for the Materials Engineering group and to make it more easily accessible to those who use it.	Derek Chen, P. Eng.

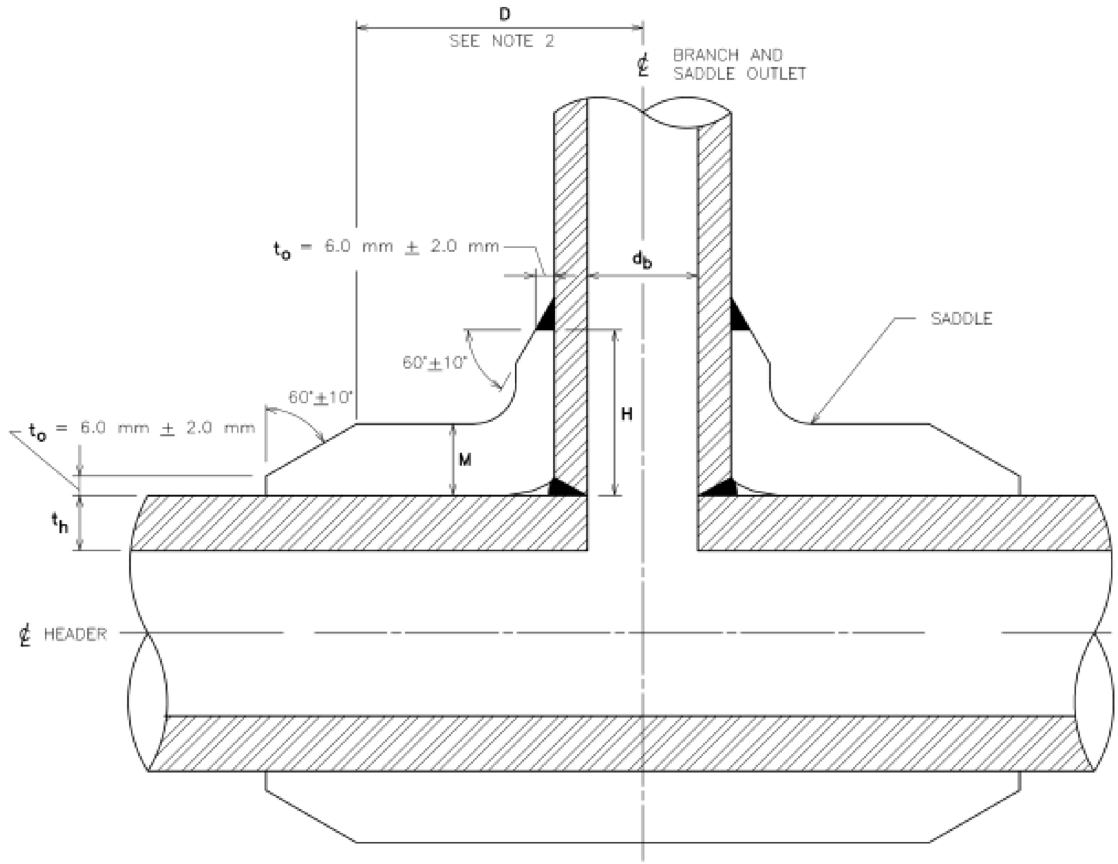
13 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A.
Industry Standards	
N/A	N/A.
General	
N/A	This Specification was updated and put into the new template.

14 APPROVALS

APPROVALS		
Originator: Sajjad Kazi, P.E. Welding and Materials Engineering	Sajjad Kazi Signature	Oct 28, 2016 Date
Reviewer: Cindy Guan, P. Eng. Welding and Materials Engineering	Signature	Oct 28, 2016 Date
Responsible Engineer: Derek Chen, P. Eng. Welding and Materials Engineering	Chen Xiande Signature Oct 28, 2016 Date	PROFESSIONAL ENGINEER XIANDE (DEREK) CHEN ALBERTA Oct 28 2016 APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, Manager Welding and Materials Engineering	J. Ferguson Signature	Oct. 28, 2016 Date

APPENDIX A DIMENSIONAL REQUIREMENTS FOR FULL ENCIRCLEMENT REINFORCING SADDLES



LEGEND:

D = DIMENSIGN FROM CENTER OF OUTLET BRANCH TO END OF FULL THICKNESS OF SADDLE

d_b = INSIDE DIAMETER OF OUTLET BRANCH

t_h = WALL THICKNESS OF HEADER PIPE

t_o = THICKNESS OF SADDLE OUTLET AT WELD BEVEL

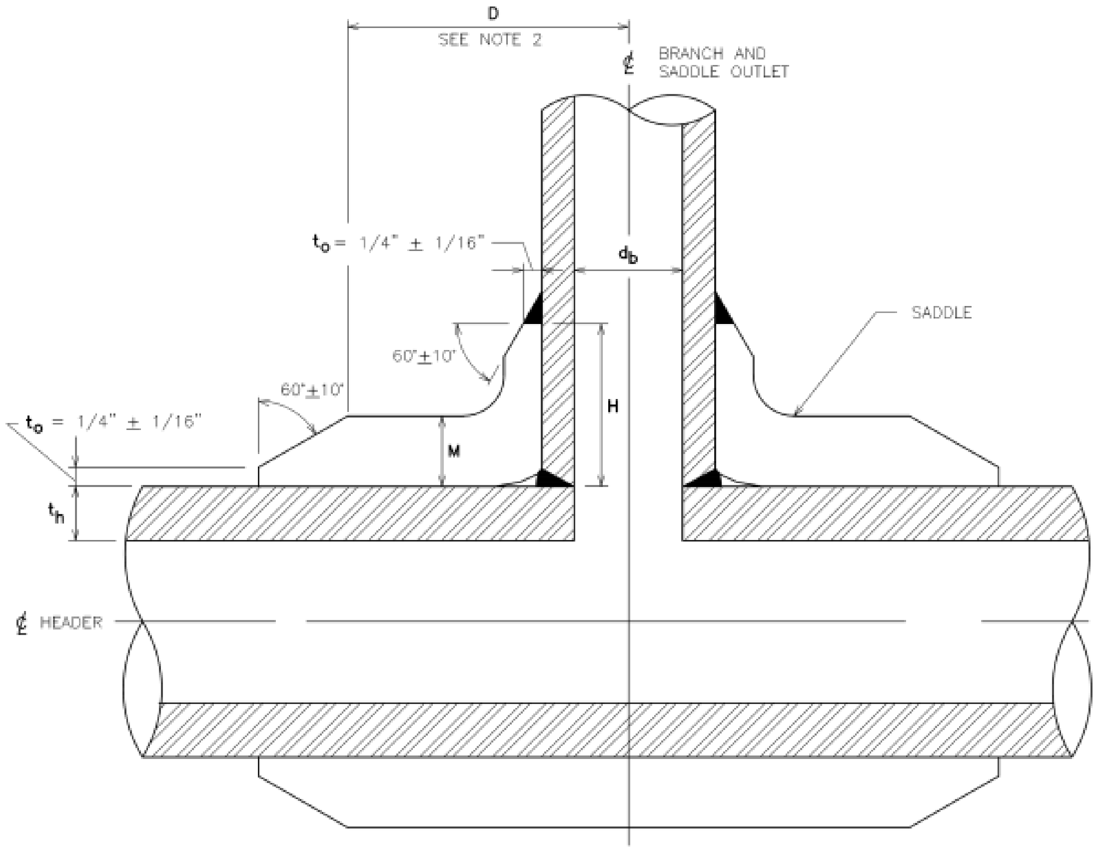
M = WALL THICKNESS OF SADDLE

H = HEIGHT OF REINFORCING OUTLET

NOTES:

1. GRIND ENDS TO ELIMINATE ALL SHARP CORNERS.
2. DIMENSION '**D**' MUST BE GREATER THAN OR EQUAL TO d_b AND NOT LESS THAN 153 mm.

Appendix Figure A-1: Dimensional Requirements for Full Encirclement Reinforcing Saddles (SI Units)



LEGEND:

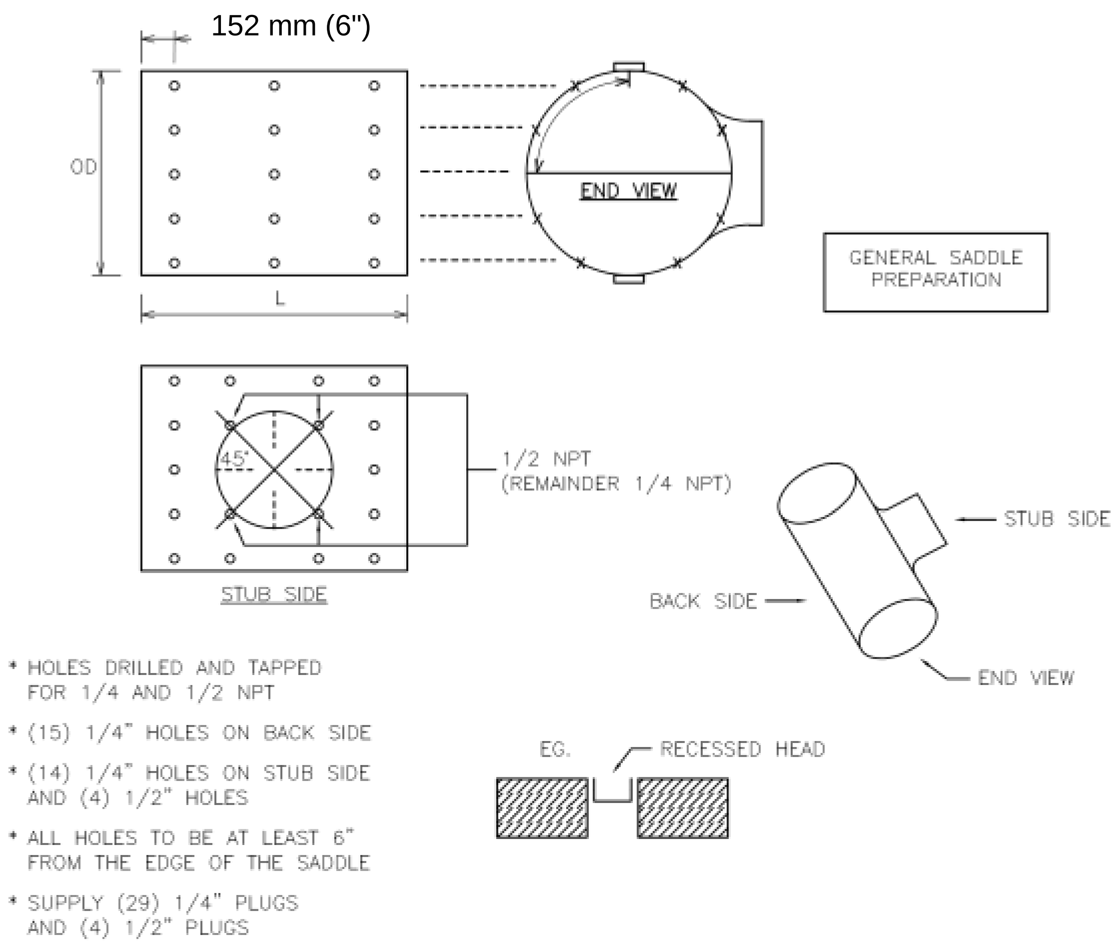
- **D** = DIMENSION FROM CENTER OF OUTLET BRANCH TO END OF FULL THICKNESS OF SADDLE
- d_b = INSIDE DIAMETER OF OUTLET BRANCH
- t_h = WALL THICKNESS OF HEADER PIPE
- t_o = THICKNESS OF SADDLE OUTLET AT WELD BEVEL
- **M** = WALL THICKNESS OF SADDLE
- **H** = HEIGHT OF REINFORCING OUTLET

NOTES:

1. GRIND ENDS TO ELIMINATE ALL SHARP CORNERS.
2. DIMENSION 'D' MUST BE GREATER THAN OR EQUAL TO d_b AND NOT LESS THAN 6".

Appendix Figure A-2: Dimensional Requirements for Full Encirclement Reinforcing Saddles (U.S. Customary Units)

APPENDIX B ARRANGEMENT OF DRILLED AND TAPPED HOLES FOR EPOXY INJECTION



Appendix Figure B-1: Arrangement of Drilled and Tapped Holes for Epoxy Injection

Note: The four ½ NPT holes shall be located in the current transition area from the run to the branch

APPENDIX C TERMS AND DEFINITIONS

Terms	Definitions
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Material
Branch Size	Nominal outside diameter of the connecting branch pipe
CFR	Code of Federal Regulations
Company or Purchaser	TransCanada PipeLines Limited, its corporate affiliate, or its agent
CSA	Canadian Standards Association
ISO	International Organization for Standardization
Manufacturer or Vendor	Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.
Material Number	The number assigned to each item on a purchase order (also known as part number, catalogue number, SAP number or material master number).
MSS	Manufacturers Standardization Society
NEB	National Energy Board
NOM	Norma Oficial Mexicana
Purchase order	The purchasing document used to purchase the specified item(s)
Purchaser	TransCanada Pipelines and its authorized representative(s) responsible for executing all or any of the engineering, procurement and construction activities
Regulatory Authority	The national and/or local regulator having jurisdiction over the facility.
Saddle	Steel casing which provides reinforcement of the welded branch connection
Saddle size	Nominal outside diameter of the header (run) pipe to which the saddle is attached
Technical Agreement	The document signed by the Company and the manufacturer, which states a mutual agreement on a technical matter.
Traceability Number	A number that will be marked on the specified item(s) to allow identification of each

Terms	Definitions
	piece. It shall consist of the letters PO, the purchase order number, the purchase order line item number, and where applicable, a numerical suffix. Note: The numerical suffix is only required when more than one piece is supplied for the same item number on the same purchase order.
Welded Branch Connection	Direct connection of pipe at 90° to the header (run) pipe by welding

TES-MATL-MD1-US Piping System Materials for Pipeline, Compression and Metering Facilities Design to -50°F		Document Type: Specification
Effective Date: 2012/03/23	Revision: 01	Status: Issued
Classification Code: ME-09	Document Owner: Materials Engineering	
Originator: Cindy Guan, P.Eng., Materials Engineering		March 23 2012 Signature/Date (signed copy on file)
Discipline Checker: Derek Chen, P. Eng., Materials Engineering		March 23, 2012 Signature/Date (signed copy on file)
Discipline Checker: Gerard Lalonde, P. Eng., Piping Support		March 23/2012 Signature/Date (signed copy on file)
Responsible Engineer: Cindy Guan, P. Eng., Materials Engineering		March 23 2012 Signature/Date (signed copy on file)

BRIEF DESCRIPTION OF CHANGE

REGULATORY

- This specification complies with the relevant sections of the Department of Transportation's Code of Federal Regulations, Title 49, Parts 192 and 195.

GENERAL.

- This specification covers the material requirements of the piping systems designed in accordance with the requirements of ASME B31.3, Process Piping; ASME B31.8, Gas Transmission and Distribution Piping Systems; ASME B31.4, Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids; and TransCanada Engineering Design Standards for use in sweet natural gas and sweet liquid hydrocarbons pipeline, compression, metering and regulating facilities outside of Canada.
- This specification is intended for material selection of new piping systems. For existing systems, the Designer shall determine the best practices providing that the modifications meet the intent of the current design requirements and the codes referenced above.
- Materials included are pipe, tubing, fittings, flanges, valves, meters, and miscellaneous piping components.

TABLE OF CONTENTS

1 GENERAL

1.1 Scope

1.1.1 Intent of Specification

This specification is for pipeline systems for minimum design temperature at -50°F that will be installed in the northern United States, refer to Annex A of TED-MATL-FRAC (Zone 1) for the mimimum design temperature zone map.

This Specification covers the material requirements of the piping systems designed in accordance with the requirements of ASME B31.3, Process Piping; ASME B31.4, Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids; ASME B31.8, Gas Transmission and Distribution Piping Systems; CFR Title 49 Part 192, Transportation of Natural Gas and Other Gas by Pipeline: Minimum Safety Standards, and any amendment or errata issued by DOT; CFR Title 49 Part 195, Transportation of Hazardous Liquids by Pipeline and any amendment or errata issued by DOT; and TransCanada Engineering Design Standards for use in sweet natural gas and sweet liquid hydrocarbons pipeline, compression, metering, and regulating facilities.

This Specification is intended for material selection of new piping systems. For existing systems, the Designer shall determine the best practices providing that the modifications meet the intent of the current design requirements and the codes referenced above.

Materials included are pipe, tubing, fittings, flanges, valves, meters, and miscellaneous piping components.

1.1.2 Limitations

All materials described in this Specification are suitable for use in the specific piping system listed in Table 1. The Designer shall select the wall thickness and pressure ratings to suit the design conditions. The selected materials shall be in conformance with the applicable engineering standards, specifications, design philosophies, and directives.

1.2 Definitions

a) Specified Minimum Yield Strength (SMYS) - The minimum yield strength prescribed by the specification or standard under which a material is manufactured.
b) ASTM - American Society for Testing and Materials
c) ASME - American Society of Mechanical Engineers
d) Piping System - A facility; including pipe, valves, fittings, flanges, vessels, and other attached appurtenances; used to convey natural gas or other fluids such as liquefied petroleum gases, air, steam, solution of ethylene glycol in water, oils used in compressor stations, and sewage effluent.

1.3 Reference Publications

1.3.1 American Society of Mechanical Engineers (ASME)

B31.3	Process Piping
B31.4	Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids

B31.8	Gas Transmission and Distribution Piping Systems
B16.5	Pipe Flanges and Flanged Fittings
B16.9	Factory-Made Wrought Steel Buttwelding Fittings
B16.11	Forged Fittings Socket Welding and Threaded
B16.20	Metallic Gaskets for Pipe Flanges, Ring-Joint Spiral Wound and Jacketed
B16.21	Nonmetallic Flat Gaskets for Pipes Flanges
B16.25	Buttwelding Ends
B16.34	Valves Flanged Threaded and Welding End
B16.47	Large Diameter Steel Flanges
B16.49	Factory –Made Wrought Steel Buttwelding Induction Bends for Transportation and Distribution Systems
B36.10	Welded and Seamless Wrought Steel Pipe
B36.19	Stainless Steel Pipe

1.3.2 ASTM

D 1527 Standard Specification for ABS Plastic Pipe Schedules 40 and 80
D 2235 Standard Specification for ABS Plastic Pipe Schedules 40 and 80
D 2466 Standard Specification for PVC Plastic Pipe Schedule 40
D 2467 Standard Specification for PVC Plastic Pipe Schedule 80

1.3.3 DOT

CFR Title 49 Part 192	Transportation of Natural Gas and Other Gas by Pipeline: Minimum Safety Standards and any amendment or errata issued by DOT
CFR Title 49 Part 195	Transportation of Hazardous Liquids by Pipeline and any amendment or errata issued by DOT

1.3.4 Manufacturers Standardization Society (MSS)

MSS SP-44	Steel Pipeline Flanges
MSS SP-75	Specification for High-Test, Wrought, Butt-Welding Fittings
MSS SP-80	Bronze Gate, Globe, Angle and Check Valves
MSS SP-83	Class 3000 Steel Pipe Unions, Socket Welding and Threaded
MSS SP-95	Swage Nipples and Bull Plugs
MSS SP-97	Integrally Reinforced Forged Branch Outlet Fittings - Socket Welding, Threaded and Buttwelding Ends

1.3.5 TransCanada Engineering Standards and Specifications

TES-PIPE-EW-US	Specification for Electric-Welded Pipe
TES-PIPE-SAW-US	Specification for Double Submerged Arc Welded Pipe
TES-FITG-EC1-US	End Closures (EC-1)
TES-FITG-CIF-US	Contoured Insert Fitting
TES-FITG-LD-US	Specification for Carbon Steel Buttwelding Fittings, Grade 290 and Higher
TES-FITG-T01-US	Instrument Tube Fitting, Instrument Pipe Fitting and Tubing Material Spec.
TES-PIPE-P8-US	Orifice Meter Tube Pipe
TES-FLGE-LD-US	Specification for Steel Flanges $\geq$ NPS 16

TES-USON-US1-US	Ultrasonic Meters
TES-VALV-LD-US	Specification for Steel Valves ≥ NPS 16
TES-MATL-PV1-US	Specification for Pressure Vessels

2 PIPING SYSTEMS

2.1 Purpose and Description

For purposes of simplifying the design and drafting procedures, and for proper identification of the materials and parts, all piping within the pipeline, compression, metering, and regulating facilities is divided into piping systems.

The piping systems are identified and described in Table 1. Materials for specific piping systems are listed in Tables 2 to 13.

2.2 Design Conditions

The materials specified for use in the piping systems containing natural gas and liquid hydrocarbons shall be designed to the requirements of ASME B31.3, ASME B31.4, ASME B31.8, and CFR Title 49 Part 192 & 195 whichever is applicable.

2.3 Abbreviations

The following abbreviations are used in this Specification:

PN	Nominal pressure class
NPS	Nominal pipe size
OD	Nominal outside diameter
ID	Nominal inside diameter
WT	Nominal wall thickness
RF	Raised face
FF	Flat face
NPT	National pipe thread
BW	Buttwelding
SW	Socket welding
SF	Socket Fusion
WNRF	Raised face welding neck
SWRF	Raised face socket welding

2.4 Tubing and Instrument Tube Fittings

All tubing and instrument tube fittings shall meet the requirements of TES-FITG-T01-US.

2.5 Unlisted Materials

Materials required for all pipeline systems and pressure containing compressor station systems shall be specified on design drawings, material requisitions, and purchase orders in accordance with this Specification. Unlisted pressure-containing components materials may be used only with the prior approval of TransCanada's Materials Engineer and in a manner that complies with the requirements for alternative materials contained in the applicable design code.

2.6 Pipe Wall Thickness

Wall thickness of pipe shall be determined in accordance with ASME B31.3, B31.4 or ASME B31.8.

As a quick reference, maximum design pressures are provided for Schedule 40 and Schedule 80 pipe that is NPS 14 and smaller in Appendices B and C.

2.7 Flanges

Maximum operating pressures for ASME flanges are listed in ASME B16.5 based on a maximum operating temperature of 100°F. Maximum operating pressures for MSS flanges are listed in MSS-SP-44 based on a maximum operating temperature of 250°F. For operation above these temperatures, the maximum operating pressures are derated in accordance with the tables in ASME B16.5/MSS-SP-44.

As a quick reference, maximum operating pressures are provided based on flange material selected and typical operating temperatures in Appendix A.

2.8 Flange Bolting and Gaskets

Dimensions of bolting and gaskets are listed in Appendices E and F. The bolting dimensions shall be adjusted for spacers and wafer type valves intended to fit between flanges.

2.9 Valves

The description of material requirements are listed in TES-VALV-LD-US.

ASME B16.34 requires valve ratings to be in accordance with the ASME B16.5 flange class rating system (e.g., Class 150, 300, 400, 600, 900). However, some manufacturers use alternate systems for pressure ratings (i.e. PN 20, 50, 68, 100, 150, 2000#, 3000#, and 6000#). When ordering valves not rated in accordance with the ASME B16.34 class rating system, written confirmation of maximum cold working pressure shall be obtained from the approved manufacturers.

2.10 Components Having Requirements for Proven Notch Toughness

For all items purchased to TransCanada specifications, the applicable design temperature shall be included with the ordering designation on design drawings, material requisitions and purchase orders.

For all pressure containing components for sweet natural gas and sweet liquid hydrocarbons service NPS 2 and larger and purchased to US industry standards, a minimum design temperature of +23°F or -50°F shall be specified on design drawings, material requisitions, and purchase orders.

2.11 Material Descriptions

Material Descriptions in Avantis shall be prepared and approved by the originating process and submitted to the Designer and Materials Engineer for final approval.

2.12 D/t Ratio

The pipe outside diameter to wall thickness ratios (D/t) should not exceed the values listed in

Appendix D. The table encompasses the more common pipe diameters used in the TransCanada system and is based on favorable manufacturing and field construction experience. For pipe diameters not included, D/t may be found by interpolation.

2.13 Coating Materials

All piping, valves and equipment shall be coated in accordance with the requirements of TransCanada coating specifications.

2.14 Threaded Connections

Except for auxiliary connections such as drains, valve body bleeds, or instrumentation taps, the use of threaded connections on permanently buried installations is not permitted. All other underground connections to components used in gas pipeline and compressor station systems shall be made by welding or by the use of flanges.

Seal welding of above and below ground threaded connections is prohibited unless otherwise approved by the Designer or Welding Specialist. Such approval would only be considered on a case by case basis.

3 TEST REPORTS

3.1 Material Less Than NPS 2

Either a Certificate of Compliance or a Material Test Report shall be supplied for all materials that are smaller than NPS 2.

3.2 Material NPS 2 and Larger

A Material Test Report shall be supplied for all materials that are NPS 2 and larger.

Table 1: Summary of Piping Systems

Piping System Designation	Fluid Handled	Design Pressure	Design Temperature	Description	Material Table
High Pressure Gas / Oil - Pipeline Facility	Sweet natural gas / oil	Designer to Specify	23°F to 167°F	Line pipe	2
High Pressure Gas / Oil - Pipeline Assemblies	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Pipeline assemblies, hot taps, crossovers (tieovers), blowdowns, launchers and receivers	3
High Pressure Gas / Oil - Meter Station	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Meter Station piping	4
High Pressure Gas / Oil - Compression Facility	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Compressor station suction, discharge and recycle piping	5
Power Gas	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Supply to operators and control devices	5
Utility Gas	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Fuel gas piping to APU, PPU, boilers and gas burning appliances	5
Compressor Fuel Gas	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Compressor fuel gas piping upstream of final fuel gas filter	5
Compressor Fuel Gas	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Compressor fuel gas piping downstream of final fuel gas filter	6
Control Gas & Seal Gas	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Control gas to instrumentation and compressor seal gas	6
Compressor Lube Oil	Mineral or PE oil	Designer to Specify	23°F to 248°F	Lubricating and make-up oil	7
Compressor Seal Oil and Hydraulic Oil	Mineral, hydraulic or PE oil	Designer to Specify	23°F to 248°F	Seal and hydraulic oil	7
Fire Suppression - Gaseous	Inergen, Halon or CO_2	Designer to Specify	-50°F to 167°F	Piping from cylinders to nozzles	8
Foam Systems & Water Mist Systems	Foam concentrate and Water	Designer to Specify	23°F to 167°F	Foam concentrate and water piping between system components	9
Potable Water	Water	80 Psig	23°F to 167°F	Fresh water, water treatment and storage	10
Heating Water	Glycol-water 50:50 mixture	160 Psig	23°F to 248°F	Glycol/water for heating	11
Jacket Cooling Water	Glycol-water 50:50 mixture	160 Psig	23°F to 248°F	Compressor package jacket cooling water piping	11
Compressed Air	Air	150 Psig	23°F to 167°F	Shop, power, bleed, and instrument air	12
Drainage	Storm, waste and effluents disposal	80 Psig	23°F to 167°F	Sanitary and storm drainage and vent	13

Table 2: High Pressure Gas / Oil - Pipeline Facility

Piping System: Pipeline Facility			**Fluid Handled: Sweet Natural Gas & Oil**	**Design Pressure: Designer to Specify**	**Design Temperature: 23°F to 167°F**
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Line Pipe	2	Bevel	API 5L Gr. B, or ASTM A106 Gr. B, or ASTM A333 Gr. 6, Seamless		
	3 to 14	Bevel	API 5L PSL 2, or ASTM A333 Gr. 6, Seamless		
	10 to 24	Bevel	TES-PIPE-EW-US		
	16 to 48	Bevel	TES-PIPE-SAW-US		
Induction Bends	All	Bevel	ASME B16.49		
3D Elbows	16 to 48	Bevel	TES-FITG-LD-US		

Table 3: High Pressure Gas / Oil - Pipeline Assemblies

Piping System: Pipeline Assemblies			Fluid Handled: Sweet Natural Gas / Oil	Design Pressure: Designer to Specify	Design Temperature: - 50°F To 167°F
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Tubing	Up to ½ ⅝ to ⅞ 1	Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Instrument Pipe Fittings	¼ to 1½	NPT	Cadmium plated carbon steel or stainless steel		
Pipe	½ to 1½ 2 3 to 14 16 to 48	Plain Bevel Bevel Bevel	API 5L Gr.B or ASTM A106 Gr. B, Sch. 80, seamless ASTM A333 Gr. 6 seamless, Sch. 80 ASTM A333 Gr. 6 seamless or API 5L PSL2 c/w toughness test @-50°F seamless, or TES-PIPE-EW-US TES-PIPE-EW-US OR TES-PIPE-SAW-US		
Pipe Fittings	½ to 1½ 2 to 14 16 to 48	SW BW BW	ASME B16.11 & ASTM A105, 3000# ASME B16.9 & ASTM A420 WPL6, to match pipe TES-FITG-LD-US, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A105, 3000#		
Mueller Tees	½ to 1½	NPT	ASTM A105, 1440 Psig		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106 Gr. B, Sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, Sch. 80		
Flanges (See Appendix A)	½ to 1½ 2 to 14 16 to 48	SWRF WNRF WNRF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1, to match pipe TES-FLGE-LD-US, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 24 26 to 48	RF RF RF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1 ASME B16.47 & ASTM A350 LF2 Class 1		
Closures	All	BW	TES-FITG-EC1-US		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A105, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A350 LF2 Class 1, XS		
CIF's	3 to 12		TES-FITG-CIF-US, min. run size NPS 20, to match WT		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.21, Wire reinforced non asbestos 1/16 in (preferred) Alternate: ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	CS or SS body, stem & bonnet; non metallic seat, 6000#		

Valves	½ to 1½ 2 to 14 16 to 48	SW or NPT RF or BW RF or BW	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D c/w toughness test @-50°F TES-VALV-LD-US
Pressure Vessels	All		TES-MATL-PV1-US

Table 4: High Pressure Gas / Oil - Meter Station

Piping System: Meter Station			Fluid Handled: Sweet Natural Gas / Oil	Design Pressure: Designer to Specify	Design Temperature: - 50°F To 167°F
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Tubing	Up to ½ ⅝ to ⅞ 1	Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 14 16 to 48	Plain Bevel Bevel Bevel	API 5L Gr. B, ASTM A106 Gr. B, seamless, Sch. 80 ASTM A333 Gr. 6, seamless, Sch. 80 ASTM A333 Gr. 6 seamless, API 5L PSL2 c/w toughness test @-50°F, or TES-PIPE-EW-US TES-PIPE-EW-US OR TES-PIPE-SAW-US		
Pipe Fittings	½ to 1½ 2 to 14 16 to 48	SW BW BW	ASME B16.11 & ASTM A105, 3000# ASME B16.9 & ASTM A420 WPL6, to match pipe TES-FITG-LD-US; to match pipe		
Instrument Pipe Fittings	¼ to 1½	NPT	Cadmium plated carbon steel or stainless steel		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A105, 3000#		
Mueller Tees	½ to 1½	NPT	ASTM A105, 1440 Psig		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106 Gr. B, Sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, Sch. 80		
Flanges (See Appendix A)	½ to 1½ 2 to 14 16 to 48	SWRF WNRF WNRF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1, to match pipe TES-FLGE-LD-US, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 24 26 to 48	RF RF RF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1 ASME B16.47 & ASTM A350 LF2, Class 1		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A105, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A350 LF2 Class 1, XS		
CIF's	3 to 6		TES-FITG-CIF-US, min. run size NPS 20, to match WT		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	CS or SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 14 16 to 48	SW or NPT RF or BW RF or BW	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D c/w toughness test @-50°F TES-VALV-LD-US		
Meters	All	WxRF or RFxRF	TES-ORIF-OF1-US (orifice), TES-TBIN-FE-US (turbine), or TES-USON-US1-US (ultrasonic)		

Piping System: Meter Station			**Fluid Handled: Sweet Natural Gas / Oil**	**Design Pressure: Designer to Specify**	**Design Temperature: - 50°F To 167°F**
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Meter Tube, Orifice	Up to 12	Bevel	TES-PIPE-P8-US		
Meter Tube, Ultrasonic	3-30	Bevel	TES-PIPE-P8-US		
Meter Tube, Turbine	Up to 12	Bevel	ASTM A333 Gr. 6, Seamless		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 5: High Pressure Gas / Oil - Compression Facility

Piping System: Compressor Plant, Power Gas, Utility Gas, and Fuel Gas u/s of Coalescing Filter			**Fluid Handled: Sweet Natural Gas / Oil**	**Design Pressure: Designer to Specify**	**Design Temperature: - 50°F To 167°F**
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 14 16 to 48	Plain Bevel Bevel Bevel	ASTM A106 Gr. B or API 5L Gr. B, Seamless, Sch. 80 ASTM A333 Gr. 6, Seamless, Sch. 80 ASTM A333 Gr. 6, Seamless or API 5L PSL2 c/w toughness test @- 50°F Seamless, or TES-PIPE-EW-US TES-PIPE-EW-US OR TES-PIPE-SAW-US		
Pipe Fittings	½ to 1½ 2 to 14 16 to 48	SW BW BW	ASME B16.11 & ASTM A105, 3000# ASME B16.9 & ASTM A420 WPL6, to match pipe TES-FITG-LD-US; to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A105, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106 Gr. B, XXS		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, XXS		
Flanges (See Appendix A)	½ to 1½ 2 to 14 16 to 48	SWRF WNRF WNRF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1, to match pipe TES-FLGE-LD-US, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 24 26 to 48	RF RF RF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1 ASME B16.47 & ASTM A350 LF2, Class 1		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A105, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A350 LF2 Class 1, XS		
CIF's	3 to 6		TES-FITG-CIF-US, min. run size NPS 20, to match WT		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		PN 20/50/68 (Class 150/300/400): ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in (preferred); PN 100/150 (Class 600/900): ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 14 16 to 48	SW or NPT RF or BW RF or BW	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D c/w toughness test @- 50°F TES-VALV-LD-US		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 6: High Pressure Gas / Oil - Compressor Fuel (d/s of filter), Control & Seal Gas

Piping System: Compressor Fuel Gas d/s of Coalescing Filter, Control & Seal Gas			**Fluid Handled: Sweet Natural Gas / Oil**	**Design Pressure: Designer to Specify**	**Design Temperature: -50°F To 167°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 6	Plain Bevel Bevel	ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316		
Pipe Fittings	½ to 1½ 2 to 6	SW BW	ASME B16.11 & ASTM A182 Gr. F304/F316, 3000# ASME B16.9 & ASTM A403 Gr. WP304/WP316, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A182, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A312 Gr. TP304/TP316, Sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A403 Gr. WP304/WP316		
Flanges (See Appendix A)	½ to 1½ 2 to 6	SWRF WNRF	ASME B16.5 & ASTM A182 Gr. F304/F316 ASME B16.5 & ASTM A182 Gr. F304/F316, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 6	RF RF	ASME B16.5 & ASTM A182 Gr. F304/F316 ASME B16.5 & ASTM A182 Gr. F304/F316		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A182 Gr. F304/F316, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A182 Gr. F304/F316, 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A182 Gr. F304/F316, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A182 Gr. F304/F316, XS		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in Alternate: ASME B16.21, Wire reinforced non asbestos, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 6	SW or NPT RF	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 7: Auxiliary Systems - Lubrication Oil, Seal Oil & Hydraulic Oil

Piping System: Lubrication Oil, Seal Oil & Hydraulic Oil			**Fluid Handled: Lube/Hydraulic Oil**	**Design Pressure: Designer to Specify**	**Design Temperature: 23°F To 248°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 6	Plain Bevel Bevel	ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316		
Pipe Fittings	½ to 1½ 2 to 6	SW BW	ASME B16.11 & ASTM A182 Gr. F304/F316, 3000# ASME B16.9 & ASTM A403 Gr. WP304/WP316, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A182, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A312 Gr. TP304/TP316, Sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A403 Gr. WP304/WP316		
Flanges (See Appendix A)	½ to 1½ 2 to 6	SWRF WNRF	ASME B16.5 & ASTM A182 Gr. F304/F316 ASME B16.5 & ASTM A182 Gr. F304/F316, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 6	RF RF	ASME B16.5 & ASTM A182 Gr. F304/F316 ASME B16.5 & ASTM A182 Gr. F304/F316		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A182 Gr. F304/F316, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A182 Gr. F304/F316, 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A182 Gr. F304/F316, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A182 Gr. F304/F316, XS		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		PN 20/50/68 (Class 150/300/400): ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in PN 100/150 (Class 600/900): ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 6	SW or NPT RF	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 8: Auxiliary Systems - Fire Suppression - Gaseous

Piping System: High Pressure Fire Suppression			**Fluid Handled: Halon/Inergen/CO_2**	**Design Pressure: Designer to Specify**	**Design Temperature: - 50°F To 167°F**
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2	Plain Bevel	ASTM A106 Gr. B, seamless, Sch. 80 ASTM A333 Gr. 6 seamless, Sch. 80		
Pipe Fittings	½ to 1½ 2	SW BW	ASME B16.11 & ASTM A105, 3000# ASME B16.9 & ASTM A420 WPL6, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A105, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106 Gr. B, XXS		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, XXS		
Flanges (See Appendix A)	½ to 1½ 2	SWRF WNRF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2	RF RF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A105, 3000# (pref.) or 6000#		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2	SW or NPT RF	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 9: Auxiliary Systems - Fire Suppression - Foam & Water Mist

Piping System: Foam Systems, Water Mist Systems			**Fluid Handled: Foam/Water**	**Design Pressure: Designer to Specify**	**Design Temperature: 23°F To +167°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 6	Plain Bevel Bevel	ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316, Sch. 40		
Pipe Fittings	½ to 1½ 2 to 6	SW BW	ASME B16.11 & ASTM A182 Gr. F304/F316, 3000# ASME B16.9 & ASTM A403 Gr. WP304/WP316, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A182, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A312 Gr. TP304/TP316, Sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A403 Gr. WP304/WP316		
Flanges (See Appendix A)	½ to 1½ 2 to 6	SWRF WNRF	ASME B16.5 & ASTM A182 Gr. F304/F316 ASME B16.5 & ASTM A182 Gr. F304/F316, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 6	RF RF	ASME B16.5 & ASTM A182 Gr. F304/F316, Class 150 ASME B16.5 & ASTM A182 Gr. F304/F316, Class 150		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A182 Gr. F304/F316, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A182 Gr. F304/F316, 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A182 Gr. F304/F316, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A182 Gr. F304/F316, XS		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 6	SW, NPT RF	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 10: Auxiliary Systems - Potable Water

Piping System: Potable Water			Fluid Handled: Fresh Water	Design Pressure: 80 Psig	Design Temperature: 23°F To 167°F
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe - Galvanized	½ to 2 3	NPT NPT	ASTM A53 Galvanized, sch. 80 for general above ground service ASTM A53 Galvanized, sch. 40 for general above ground service		
Pipe - Copper	All	Plain	ASTM B88 Type L hard, for above ground control/service building only ASTM B88 Type K soft, for below ground control/service building only		
Pipe - CPVC	½ to 2	Plain	ASTM D 2241		
Pipe - Polyethylene	½ to 2	Plain	ASTM D 2239		
Fittings - Galvanized	½ to 3	NPT	ASME B16.11 & ASTM A105 Galvanized, 3000#		
Fittings - Copper	All	Soldered	ASME B16.22		
Fittings - CPVC	½ to 2	SF	ASTM D 2466		
Fittings -Polyethylene	½ to 2	SF	ASTM D 2239		
Unions	½ to 3	NPT	MSS-SP-83 & ASTM A105 Galvanized, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A53 Galvanized, sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB Galvanized, sch. 80		
Flanges (See Appendix A)	½ to 3	RF, NPT	ASME B16.5 & ASTM A105 Galvanized, Class 150		
Blind Flanges (See Appendix A)	½ to 3	RF	ASME B16.5 & ASTM A105 Galvanized, Class 150		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105 Galvanized, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB Galvanized, 6000# (solid)		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 3	Soldered or NPT	MSS SP 80, Class 125 bronze body		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 11: Auxiliary Systems - 50:50 Water/Glycol

Piping System: Heating & Cooling Water			**Fluid Handled: 50:50 Water/Glycol**	**Design Pressure: 160 Psig**	**Design Temperature: 23°F To 248°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 8	Plain Bevel Bevel	API 5L Gr.B or ASTM A106 Gr. B, sch. 80, seamless API 5L Gr.B or ASTM A106 Gr. B or A333 Gr. 6 seamless, sch. 80 API 5L PSL2 or ASTM A333 Gr. 6 seamless, sch. 40		
Pipe Fittings	½ to 1½ 2 to 8	SW BW	ASME B16.11 & ASTM A105, 3000# MSS-SP-75 or ASTM A420 WPL6, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A105, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106 Gr. B, XXS		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, XXS		
Flanges	½ to 1½ 2 to 8	SWRF WNRF	ASME B16.5 & ASTM A105, Class 150 ASME B16.5 (for dimension only) & MSS-SP-44 or ASTM A350 LF2 Class 1, Class 150, to match pipe		
Blind Flanges	½ to 1½ 2 to 8	RF RF	ASME B16.5 & ASTM A105, Class 150 ASME B16.5 (for dimension only) & MSS-SP-44 & ASTM A350 LF2 Class 1, Class 150		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A105, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A105 XS or A350 LF2 Class 1, XS		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 8	SW, NPT RF	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 12: Auxiliary Systems - Compressed Air

Piping System: Shop and Instrument Air			**Fluid Handled: Air**	**Design Pressure: 150 Psig**	**Design Temperature: 23°F To 167°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2	NPT NPT	API 5L Gr.B or ASTM A106 Gr. B, sch. 80, seamless API 5L Gr.B or ASTM A106 Gr. B or ASTM A333 Gr. B, sch. 80, seamless		
Pipe Fittings	½ to 2	NPT	ASME B16.11 & ASTM A105, 3000#		
Unions	½ to 2	NPT	MSS-SP-83 & ASTM A105, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106, sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, sch. 80		
Flanges	½ to 2	RF, NPT	ASME B16.5 & ASTM A105, Class 150		
Blind Flanges	½ to 2	RF	ASME B16.5 & ASTM A105, Class 150		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB, 6000# (solid)		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2	SW or NPT RF or NPT	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 13: Auxiliary Systems - Drainage

Piping System: Drainage			**Fluid Handled: Effluents**	**Design Pressure: 80 Psig**	**Design Temperature: 23°F To 167°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
ABS Pipe	All	Plain	ASTM D 2661		
PVC Pipe	All	Plain	ASTM D 2665		
Carbon Steel Pipe	2 to 10	Bevel	API 5L PSL2 or ASTM A333 Gr. 6, Seamless (for compressor floor drainage to holding tank)		
Pipe Fittings	2 3 to 10	BW BW	ASME B16.9 & ASTM A420 WPL6, to match pipe MSS-SP-75 to match pipe		
Cast Iron to Steel Pipe Connections	All	Mechanical Joint	Stainless Steel Clamp & Viton Sheet		
ABS Fittings	All	Solvent Weld	ASTM D 2235		
PVC Fittings	All	Solvent Weld	Solvent cement – ASTM D2564		

Appendix A: Maximum Design Pressures for Flanges Derated for Temperature Effects

For all design temperatures over 100°F the derating factor for ASME flanges shall be calculated in accordance with the requirements of ASME B16.5.

The following are maximum design pressures for a design temperature of 100°F and lower, and for the two maximum design temperatures shown in Tables 2 to 13.

Flange Material	Maximum Design Pressure (psig) @ 100°F & Lower Design Temperature					
	Sizes (NPS)	Class 150 PN 20	Class 300 PN 50	Class 400 PN 68	Class 600 PN 100	Class 900 PN 150
ASTM A105 or A350 LF2 Class 1	½ to 14	285	740	985	1480	2220
ASTM A182 Gr. F304	½ to 14	275	720	960	1440	2160
ASTM A182 Gr. F316	½ to 14	275	720	960	1440	2160
TES-FLGE-LD-US	16 to 48	285	740	990	1480	2220

Flange Material	Maximum Design Pressure (psig) @ 167°F Design Temperature					
	Sizes (NPS)	Class 150 PN 20	Class 300 PN 50	Class 400 PN 68	Class 600 PN 100	Class 900 PN 150
ASTM A105 or A350 LF2 Class 1	½ to 14	268	700	931	1400	2096
ASTM A182 Gr. F304	½ to 14	245	640	853	1279	1919
ASTM A182 Gr. F316	½ to 14	248	653	870	1306	1959
TES-FLGE-LD-US	16 to 48	285	740	990	1480	2220

Flange Material	Maximum Design Pressure (psig) @ 248°F Design Temperature					
	Sizes (NPS)	Class 150 PN 20	Class 300 PN 50	Class 400 PN 68	Class 600 PN 100	Class 900 PN 150
ASTM A105 or A350 LF2 Class 1 or MSS-SP-44	½ to 14	246	668	888	1336	2001
ASTM A182 Gr. F304	½ to 14	218	571	759	1140	1711
ASTM A182 Gr. F316	½ to 14	225	591	787	1182	1774
TES-FLGE-LD-US	16 to 48	285	740	990	1480	2220

Notes:

1. For design temperatures between those shown, calculate the maximum design pressure in accordance with the requirements of ASME B16.5. Do not interpolate between pressure classes.

Appendix B: Maximum Design Pressures of ASTM A106 Gr. B, API 5L Gr. B and ASTM A333 Gr. 6 (35,000 psi) Pipe

Maximum Design Pressures (psi)								
Nominal Size (NPS)	Schedule 40				Schedule 80			
	W.T.	Class 2	Class 3	Class 4	W.T	Class 2	Class 3	Class 4
¼	Schedule 40 not permitted for NPS 2 & under				**0.119**	9256	7713	6170
½					**0.147**	7350	6125	4900
¾					**0.154**	6160	5133	4107
1					**0.179**	5717	4764	3811
1¼					**0.191**	4833	4027	3222
1½					**0.200**	4421	3684	2947
2					**0.218**	3855	3213	2570
3	**0.216**	2592	2160	1728	**0.300**	3600	3000	2400
4	**0.237**	2212	1843	1475	**0.337**	3145	2621	2097
6	**0.280**	1775	1479	1183	**0.432**	2739	2282	1826
8	**0.322**	1568	1307	1045	**0.500**	2435	2029	1623
10	**0.365**	1426	1188	951	**0.594**	2321	1934	1547
12	**0.406**	1337	1115	892	**0.688**	2266	1889	1511
14	**0.438**	1314	1095	876	**0.750**	2250	1875	1500

Notes:

1. The calculations in the above table are based on ASME B31.8. Different maximum design pressures are applicable for the ASME B31.3 design code.
2. For Class 2, a design factor of 0.60 was used. A lower design factor applies to some Class 2 locations.
3. For Class 3, a design factor of 0.50 was used.
4. For Class 4, a design factor of 0.40 was used.

Appendix C: Maximum Design Pressures of ASTM A312 Gr. TP304/TP316 (30,000 psi) Pipe

Maximum Design Pressures (psi)								
Nominal Size (NPS)	Schedule 40				Schedule 80			
	W.T.	Class 2	Class 3	Class 4	W.T	Class 2	Class 3	Class 4
¼	Schedule 40 not permitted for NPS 2 & under				0.119	7933	6611	5289
½					0.147	6300	5250	4200
¾					0.154	5280	4400	3520
1					0.179	4900	4084	3267
1¼					0.191	4142	3452	2761
1½					0.200	3789	3158	2526
2					0.218	3304	2754	2203
3	0.216	2222	1851	1481	0.300	3086	2571	2057
4	0.237	1896	1580	1264	0.337	2696	2247	1797
6	0.280	1522	1268	1014	0.432	2347	1956	1565
8	0.322	1344	1120	896	0.500	2087	1739	1391
10	0.365	1222	1019	815	0.594	1989	1658	1326
12	0.406	1146	955	764	0.688	1943	1619	1295
14	0.438	1126	939	751	0.750	1929	1607	1286

Notes:
1. The calculations in the above table are based on ASME B31.8. Different maximum design pressures are applicable for the ASME B31.3 design code.
2. For Class 2, a design factor of 0.60 was used. A lower design factor applies to some Class 2 locations.
3. For Class 3, a design factor of 0.50 was used.
4. For Class 4, a design factor of 0.40 was used.

Appendix D: Maximum Pipe Diameter to Wall Thickness Ratios & Minimum Wall Thickness

Pipe Dia. (NPS)	D/t Ratio		Pipeline Min. W.T. (in)	Compressor Station Min. W.T. (in)
	EW	SAW		
3	28	-	0.126	0.217
4	36	-	0.126	0.236
6	53	-	0.126	0.280
8	55	-	0.157	0.323
10	57	-	0.189	0.366
12	68	-	0.189	0.406
14	67	-	0.209	0.437
16	73	73	0.220	0.500
20	91	91	0.220	0.500
24	95	95	0.252	0.500
30	-	104	0.287	0.500
36	-	111	0.323	0.500
42	-	119	0.354	0.500
48 and larger	-	119	0.402	0.500

Appendix E: Flange Bolting and Gaskets for NPS 14 and Smaller

Flange Size NPS	Flange Rating	Stud Dimensions			Gasket Dimensions	
		Diameter (in)	Length (in)	Qty/Flange	OD (in)	ID (in)
1	Class 150	0.500	2.50	4	2.64	1.26
	Class 300	0.625	3.00	4	2.87	1.26
	Class 600	0.625	3.50	4	2.87	1.26
	Class 900	0.875	5.00	4	3.15	1.26
1½	Class 150	0.500	2.75	4	3.39	2.13
	Class 300	0.750	3.50	4	3.74	2.13
	Class 600	0.750	4.25	4	3.74	2.13
	Class 900	1.000	5.50	4	3.90	2.13
2	Class 150	0.625	3.375	4	4.13	2.36
	Class 300	0.625	3.50	8	4.37	2.36
	Class 600	0.625	4.25	8	4.37	2.20
	Class 900	0.875	5.75	8	5.63	2.05
3	Class 150	0.625	3.50	4	5.39	3.50
	Class 300	0.750	4.25	8	587	3.50
	Class 600	0.750	5.00	8	587	3.19
	Class 900	0.875	5.75	8	6.61	3.19
4	Class 150	0.625	3.50	8	6.89	4.49
	Class 300	0.750	4.50	8	7.13	4.49
	Class 600	0.875	5.75	8	7.64	4.17
	Class 900	1.125	6.625	8	8.15	4.17
6	Class 150	0.750	4.00	8	8.74	6.61
	Class 300	0.750	4.75	12	9.88	6.61
	Class 600	1.000	6.625	12	10.51	6.18
	Class 900	1.125	7.625	12	11.38	6.18
8	Class 150	0.750	4.25	8	10.98	8.62
	Class 300	0.875	5.50	12	12.13	8.62
	Class 600	1.125	7.50	12	12.64	8.27
	Class 900	1.375	8.625	12	14.13	8.27
10	Class 150	0.875	4.50	12	13.39	10.75
	Class 300	1.000	6.25	16	14.25	10.75
	Class 600	1.250	8.50	16	15.75	10.24
	Class 900	1.375	9.25	16	17.13	10.24
12	Class 150	0.875	4.75	12	16.14	12.76
	Class 300	1.125	6.625	16	16.61	12.76
	Class 600	1.250	8.625	20	17.99	12.52
	Class 900	1.375	10.00	20	19.65	12.36
	Class 150	1.125	5.325	12	17.76	14.17

Flange Size NPS	Flange Rating	Stud Dimensions			Gasket Dimensions	
		Diameter (in)	Length (in)	Qty/Flange	OD (in)	ID (in)
14	Class 300	1.125	7.125	20	19.13	14.17
	Class 600	1.375	9.25	20	19.37	13.74
	Class 900	1.500	10.875	20	20.51	13.50

Appendix F: Flange Bolting and Gaskets for NPS 16 and Larger

Flange Size NPS	Flange Rating	Stud Dimensions			Gasket Dimensions	
		Diameter (in)	Length (in)	Qty/Flange	OD (in)	ID (in)
16	Class 600	1.50	12.00	20	22.24	15.75
	Class 900	1.625	13.50	20	22.64	15.51
18	Class 600	1.875	12.75	20	24.13	17.68
	Class 900	1.875	15.50	20	25.12	17.52
20	Class 600	1.625	13.50	24	26.89	19.69
	Class 900	2.00	16.50	20	27.52	19.49
24	Class 600	1.875	15.50	24	31.14	23.74
	Class 900	2.50	20.75	20	32.99	23.74
30	Class 600	2.00	17.00	28	38.27	29.76
	Class 900	3.00	23.50	20	39.76	30.51
36	Class 600	2.50	19.50	28	44.49	36.14
	Class 900	3.50	26.75	20	47.24	36.26
42	Class 600	2.50	23.00	28	47.99	42.01
	Class 900	3.50	29.50	24	51.26	43.74
48	Class 600	2.75	25.50	32	54.76	47.99
	Class 900	4.00	33.50	24	58.50	50.00

Note:

1. Bolt lengths for flange sizes NPS 16 to 48 include allowance to accommodate hydraulic tensioning. Class 600 and Class 900 gaskets for sizes NPS 2 to 48 are spiral wound type with inner and external ring.

- END OF DOCUMENT -

PURPOSE

This Specification provides Company requirements for the qualification, manufacture, inspection, and testing of pressure containing equipment components.

SCOPE / APPLICABILITY

This Specification includes specific materials requirements and is intended for use in conjunction with, and as a supplement to, the applicable pressure containing equipment specifications.

This Specification applies to equipment components designed to match CSA Z245.1 Grade 241 through Grade 550 (API 5L Grade B and Grades X42 through X80) pipe, such as pressure containing measurement devices, control valves, pressure relief valves, and regulators.

This Specification applies to pressure containing equipment components intended for installation in non-sour natural gas and non-sour liquid hydrocarbon pipeline systems NPS 4 or greater.

The Responsible Engineer shall be contacted for clarification if needed.

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1 GENERAL

This Specification is intended for use in conjunction with, and as a supplement to, the applicable pressure containing equipment specifications and provides materials requirements additional to those specifications.

All pressure-containing equipment components shall conform to the following requirements:

- The manufacturer shall supply the Company, at the time of quotation, any exceptions or alternatives to the requirements outlined in this specification. Items covered by technical agreements need not be addressed at the time of quotation since the technical agreements apply to each order.

2 DESIGN REQUIREMENTS

The following requirements apply to the design of pressure-containing equipment components.

2.1 End flanges

The following design requirements apply to end flanges that are part of the equipment:

- End flanges shall be weld neck or integrally cast/forged flanges with a raised face for pressure class PN 150 (ASME Class 900) or lower.
- End flanges shall have ring joint facing for pressure classes higher than PN 150 (ASME Class 900).

2.2 Field Weld Ends

The following design requirements apply to field weld ends:

- Field weld ends shall be bevelled in accordance with CSA Z662, Fig. 7.1; ASME B31.4, Fig. 434.8.6-1; or ASME B31.8, Appendix I, Figure I-4.
- The specified minimum yield strength (SMYS) of equipment components used for field weld ends shall preferably be equal to or greater than that of the matching pipe.
- In no case shall the SMYS of the equipment component used for field weld ends be less than 2/3 of that of the matching pipe.

3 MATERIALS REQUIREMENTS

Unless a different temperature is specified on the request for quote or purchase order:

- all materials shall be suitable for service at the minimum design temperature of -45°C (-50°F), and shall meet the requirements of this Specification
- all materials shall be suitable for exposure to sweet natural gas, containing by-products of processing and treating natural gas, or sweet hydrocarbon liquids.

3.1 Materials for Bolting for Equipment

Bolting used for pressure retention purposes shall be manufactured in accordance with the requirements of ASTM A194 Gr. 4 or Gr. 7, or ASTM A320 Gr. L7 or L7M.

3.2 Materials for Equipment Components Other Than Bolting

Materials selected for equipment components other than bolting shall be submitted for review and written acceptance by the Company prior to manufacture.

3.2.1 Heat Treatment of Test Specimens

Test specimens for mechanical tests shall be given the same heat treatment as the part they represent.

For equipment components that have been tempered or stress-relieved, the component need not be retested after any subsequent re-heat treatment operation is performed provided that the subsequent re-heat treatment is performed at or below the temperature of the original temper or stress relief operation.

3.2.2 Carbon Equivalent

For NPS 16 and larger equipment, a product analysis shall be conducted for each heat of material to be used for field weld ends. The sample shall be analyzed for carbon, manganese, phosphorous, sulphur, silicon, chromium, molybdenum, vanadium, copper, and nickel.

It shall be permissible to take material for the product analysis from the test coupon that is used for the mechanical tests for the same heat of steel or from a casting or forging from the same heat of steel.

For NPS 16 and larger equipment, the carbon equivalent (C.E.) shall be calculated for each heat of material to be used for field weld ends. The carbon equivalent shall not exceed 0.50 as calculated using the following equation:

$$C.E. = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

3.3 Notch Toughness

All carbon steel equipment components shall be Charpy V-notch tested in accordance with the requirements of ASTM A370, except:

- equipment components less than NPS 4
- bolting material 12.7 mm (1/2 in) and less in diameter
- nuts of any size
- equipment components manufactured from austenitic stainless steel

3.3.1 Test Specimen

Charpy V-notch tests shall be performed on the largest practical specimen size.

- The minimum average energy absorption value for any test shall be 27 J (20 ft·lb) based on full-size specimens.
- Where sub-size specimens must be used, the minimum energy absorption requirement shall be 27 J (20 ft·lb) multiplied by the ratio of the specimen width to 10 mm (0.394 in).

3.3.2 Test Temperature

Tests shall be performed at -45°C (-50°F) unless a different temperature is specified on the request for quote or purchase order. Materials tested at lower temperatures than specified shall be acceptable if the specified absorbed energy value is met at the lower test temperature.

4 PREPRODUCTION REQUIREMENTS

The Company shall supply the manufacturer with a request for quote and purchase order describing the operating conditions for which the equipment components are intended.

Prior to the commencement of production, the Manufacturer shall submit, or have previously submitted, to the Company the documents in Table 4-1 and shall have received written acceptance from the Company unless otherwise specified. The Manufacturer shall inform the Company in writing of any changes to the documents and shall obtain the written acceptance of the Company for such changes.

Table 4-1: Preproduction Documentation Requirements

Item	Requirements
Copy of quality program	See Section 5.1
Copy of the quality program registration certificate	See Section 5.1
List of materials	Materials for each equipment component (see Section 3.2).
Welding procedures	See Section 2.4.2
Pressure test procedure	See Section 2.5
Definition of critical sections	See Section 7.1.1
Drawings	Drawings shall include: • Outline dimensions • Weld end dimensions • Welding procedure and revision numbers to be used for welds (see Section 5.2) • Serial Number • Bill of Materials for equipment components, including material designations • Traceability numbers

Item	Requirements
	• Purchase order number • The Company material number • The Company specification and revision date

5 MANUFACTURING REQUIREMENTS

The following requirements apply to the manufacturer and manufacturing process.

5.1 Quality Program

The manufacturer shall have and adhere to a documented quality program accepted in writing by the Company prior to production (e.g., ISO 9001). The quality program shall be registered with an independent registrar.

5.2 Welding Qualification

Welding procedures for the following welds shall be submitted for review and written acceptance by the Company prior to use:

- Type 1: Pressure-containing fabrication welds
- Type 2: Welds defined by the Company as critical
- Type 3: Weld repairs to the welds defined in type 1 and 2
- Type 4: Weld repairs to cast equipment components that will be used on NPS 16 and larger equipment

The following weld procedure requirements apply to the four weld types defined above:

- Welds shall be made using welders and welding procedures qualified in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section IX.
- Welding procedure qualifications shall include impact testing in the weld and heat-affected zone and the requirements of Section 3.3.1 shall be met.
- Specimen quantity, location, and orientation shall be in accordance with the requirements of Paragraphs UG-84(g) and UG-84(h)(3) of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
- Welding procedures shall include micro-hardness traverses across the weld, heat-affected zones, and parent metal. The micro-hardness tests shall be performed in accordance with the requirements of ASTM Standard E384. The maximum hardness shall be 350 HV using a load of 1000 g or less.

  Note: For Type 4 welds, this is only required for welds that are not heat-treated.

Welds not defined above shall be made using welders and welding procedures qualified in accordance with the requirements of the applicable material specification or ASME Boiler and Pressure Vessel Code, Section IX.

Where cast equipment components are obtained from a sub-vendor, the equipment manufacturer shall be responsible for obtaining the required weld repair procedures.

5.3 Plant Access

While work on the contract is being performed, the Company or its representative shall have free entry at all reasonable times to all parts of the Manufacturer's facilities involved in the production of the end closures ordered. All reasonable facilities shall be provided to the Company or its representative to satisfy that the product is being furnished in accordance with this Specification, related specifications, and the purchase order.

5.4 Painting and Coating

All equipment shall be painted/coated in accordance with TES-COAT-P1 Paint Systems for Above Ground Facilities Specification (CND-US-MEX) (EDMS No. 3694704) for the installation locations as specified in the request for quote and purchase order.

6 PRESSURE AND OPERATIONAL TEST REQUIREMENTS

All equipment ordered to this Specification shall be subjected to a shell hydrostatic pressure test. There shall be no leakage for the duration of the pressure test and no permanent distortion as a result of the pressure test.

The written pressure test procedures shall be submitted for review and written acceptance by the Company prior to use. The last portion of the shell test shall be conducted in the presence of the Company's representative unless otherwise agreed in writing by the Company.

Continuous recording charts demonstrating test pressures, temperatures, and durations shall be provided for tests with a duration of one hour or longer. Where continuous recording charts are not required, the minimum test duration and minimum test pressure achieved shall be reported.

- The test charts and test records shall be certified by the manufacturer and submitted to the Company in accordance with the requirements of Section 4.
- The minimum shell test duration shall be in accordance with the requirements in Table 6-1.
- The minimum shell test pressure shall be 1.5 times the rated cold working pressure.

Table 6-1: Minimum Shell Test Duration by Component Size

Nominal Component Size	Minimum Test Durations (minutes)	
	Shell Test – Cast Items	Shell Test – Fabricated or Wrought Items
NPS 2 to NPS 4 incl.	15	5
NPS 6 to NPS 10 incl,	30	15
NPS 12 to NPS 14 incl,	30	15

Nominal Component Size	Minimum Test Durations (minutes)	
	Shell Test – Cast Items	Shell Test – Fabricated or Wrought Items
NPS 16 to NPS 18 incl.	120	30
NPS 20 to NPS 36 Incl.	240	60
Larger than NPS 36	240	120

6.1 Operational Tests

Operational testing shall be as specified in the applicable equipment specification.

7 INSPECTION REQUIREMENTS

All tests and inspections required by this specification shall be performed in the Manufacturer's plant prior to shipment. Tests and inspections shall be conducted to cause no undue interference with the operations of the Manufacturer's plant. The Company reserves the right to witness any test but it does not constitute a hold point unless explicitly identified.

Third party inspection requirements only apply for a nominal size of NPS 16 and larger unless otherwise specified on the purchase order.

7.1 Nondestructive Examination (NDE)

The following requirements apply to NDE of pressure-containing castings and welds, as well as reporting NDE results.

7.1.1 Cast Equipment Components

All castings for NPS 16 and larger equipment shall be fully inspected by magnetic particle examination in accordance with the requirements of MSS SP-53.

Critical sections of pressure-containing cast components shall be defined by the Manufacturer and accepted in writing by the Company.

Critical sections and weld repairs to critical sections of cast components used on NPS 16 and larger equipment shall be inspected by film radiography, in accordance with the requirements of MSS SP-54 or in accordance with a Company accepted ultrasonic inspection procedure.

7.1.2 Welds

All NDE conducted shall meet the requirements of the applicable paragraph or appendix of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 shown below:

- Radiographic inspection: Paragraph UW51
- Ultrasonic inspection: Appendix 12
- Magnetic particle inspection: Appendix 6
- Liquid penetrant inspection: Appendix 8

Table 7-1 outlines the acceptable NDE methods for use on different weld types.

Table 7-1: Acceptable NDE Method by Weld Type

Weld Type		Acceptable NDE Methods	
		Radiographic or Ultrasonic Inspection	Magnetic Particle or Liquid Penetrant Inspection
1	Pressure-containing fabrication welds.	✓	-
2	Welds defined by the Company as critical.	✓	-
3	Weld repairs to weld types 1 and 2.	✓	-
4	Major weld repairs to pressure containing parts on NPS 16 and larger equipment components.	✓	-
6	Welds joining a component smaller than NPS 2 to a pressure-containing part.	-	✓
7	Welds joining a non-pressure-containing part to a pressure-containing part (e.g., lifting lugs).	-	✓

7.1.3 Reporting

All radiographs for pressure-containing fabrication welds and for repairs to such welds shall be identified and shall be available for the Company's representative to view.

A written record of all nondestructive inspection results required by Section 7.1.1 and 7.1.2 shall be prepared and certified by the manufacturer for submission to the Company in accordance with the requirements of Section 9.

7.2 Defect Criteria and Repair of Defects

Equipment components containing defects shall be addressed through one of the following approaches:

- The defect shall be removed, provided that the remaining wall thickness is within the limits specified in the applicable material specification.
- The defect shall be removed and the component repaired by welding, provided that:
  - o The qualification of the welders and welding procedures is in accordance with the requirements of Section 5.2.
  - o The weld repair is inspected in accordance with the requirements of Section 7.1.
  - o All major weld repairs to equipment components that will be used on NPS 16 and larger equipment shall be heat-treated.
- The component shall be rejected.

8 MARKING REQUIREMENTS

Equipment shall have stainless steel nameplates marked with the following information as a minimum:

- Equipment Manufacturer's identification,
- Nominal size and total weight,
- Pressure class if applicable,
- Internal diameter,
- Minimum design temperature in degrees Celsius (degrees Fahrenheit),
- Traceability numbers,
- Body design code, flange design code and field weld end material,
- Positive flow direction if applicable,
- Operating pressure and temperature range,
- Maximum and minimum actual (at flowing conditions) volumetric flow rate per hour if applicable, and
- Purchase order number.

Additional markings shall be as per the applicable equipment specification.

Additional markings desired by the manufacturer are permitted. However, information on interpreting these additional markings shall be provided to the Purchaser.

9 CERTIFICATION PACKAGE

The manufacturer shall supply to the Company, prior to shipping the equipment, reports and test certificates correlated to the equipment serial number and the traceability number.

The reports and test certificates shall contain the following information:

- Product analysis and carbon equivalent of field weld ends of NPS 16 and larger equipment.
- Mechanical and chemical test results for each equipment component, including the mating flange if one is required.
- Certificate of compliance for bolting for equipment.
- Certificate of compliance for bolting supplied to attach the mating flange to the equipment, where such bolting is required.
- Test records from pressure tests.
- A written record of all nondestructive inspection results required by Section 7.1 shall be prepared and certified by the manufacturer for submission to the Company.

These records shall identify the procedure number and revision level used for the inspection.

- Confirmation that the equipment has been manufactured in accordance with the requirements of this Specification.
- Purchase order number.
- Make of equipment.
- Model.
- Serial number.
- Traceability number.
- Equipment size.
- A copy of the Company accepted drawing.
- Identification of the welding procedures and revision numbers used.

10 GLOSSARY

Terms and definitions related to this Specification can be found in APPENDIX A.

11 REFERENCES

This document relies on a number of references to legislation (act, statutes, and regulations), certificates, and orders and may include directives, guidelines, standards, and codes to the extent they contain legally binding requirements for TransCanada.

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 11-1.

Table 11-1: External and Internal References

Document No.	Title
Legal Requirements	
NEB OPR SOR/99-294	National Energy Board Onshore Pipeline Regulations (NEB OPR)
Various	Applicable Provincial Regulations for Provincially Regulated Systems
49 CFR 192	Code of Federal Regulations, Title 49 Part 192, Transportation of Natural Gas and Other Gas by Pipeline: Minimum Federal Safety Standard
49 CFR 195	Code of Federal Regulations, Title 49 Part 195, Transportation of Hazardous Liquids by Pipeline: Minimum Federal Safety Standard
NOM-007-SECRE	Transporte de Gas Natural (Where applicable)
Industry Codes and Standards	

Document No.	Title
CSA Z662	Canadian Standards Association (CSA) Oil and Gas Pipeline Systems
CSA Z245.12	Steel Flanges
CSA Z245.15	Steel Valves
ASME B31.3	American Society of Mechanical Engineers (ASME) Process Piping
ASME B31.4	Pipeline Transportation Systems for Liquids and Slurries
ASME B31.8	Gas Transmission and Distribution Piping Systems
ASME B16.5	Pipe Flange and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard
ASME B16.34	Valves — Flanged, Threaded, and Welding End
ASME B16.47	Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard
ASME BPVC-VIII	ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Rules for Construction of Pressure Vessels
ASME BPVC-IX	ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications
ASTM A216	American Society for Testing and Materials (ASTM) Standard Specification for Steel Casting, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A350	Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components
ASTM A352	Standard Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service
ASTM A516	Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A194	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A320	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service
ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM E384	Standard Test Method for Knoop and Vickers Hardness of Materials
ISO 9001	Quality management systems – Requirements

Document No.	Title
MSS SP-53	Manufacturers Standardization Society (MSS) Quality Standard for Steel Castings and Forgings for Valves, Flanges and Fittings and Other Piping Components - Magnetic Particle Exam Method
MSS SP-54	Quality Standard for Steel Castings for Valves, Flanges, and Fittings and Other Piping Components - Radiographic Examination Method
Internal References – Documents that Reference this Specification	
N/A	N/A
Internal References – Documents Referenced by this Specification	
EDMS No. 3694704	TES-COAT-P1 Paint Systems for Above Ground Facilities Specification (CDN-US-MEX)

12 DOCUMENT HISTORY

Rev.		
01	Description	Effective Date
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	Responsible Engineer
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Derek Chen, P. Eng.
	Impact Assessment Summary	Document Owner
	This specification was revised to streamline the documentation required for the Materials Engineering group and to make it more easily accessible to those who use it.	Derek Chen, P. Eng.

13 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A.
Industry Standards	
N/A	N/A.
General	
N/A	This Specification was updated and put into the new template.

14 APPROVALS

APPROVALS		
Originator: Cindy Guan, P. Eng. Welding and Materials Engineering	Signature	Oct 31, 2016 Date
Reviewer: Sandra Kleinsasser. EIT Welding and Materials Engineering	Signature	Oct. 31, 2016 Date
Responsible Engineer: Derek Chen, P. Eng. Welding and Materials Engineering	Signature Oct 31, 2016 Date	PROFESSIONAL ENGINEER (DEREK) XIANDE CHEN ALBERTA Oct 31, 2016 APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, Manager Welding and Materials Engineering	Signature	Nov. 1, 2016 Date

APPENDIX A TERMS AND DEFINITIONS

Terms	Definitions
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Material
Bolting	Bolts, studs, cap screws, and nuts
CFR	Code of Federal Regulations
Company or Purchaser	TransCanada PipeLines Limited, its corporate affiliate, or its agent
CSA	Canadian Standards Association
DOT	United States Department of Transportation
Equipment component	A pressure containing part used in the manufacture of a specific piece of equipment, i.e., measurement devices, control valves, pressure relief valves, and regulators, etc.
Heat treatment	One or more of the following methods: • Stress relieving • Normalizing • Normalizing and tempering • Quenching and tempering
ISO	International Organization for Standardization
Major weld repair	One or more of the following in the parent metal of casting: • A weld repair that is made to correct leakage: • When the depth of the cavity prepared for welding exceeds 20% of the actual wall thickness or 1 inch, whichever is smaller. • When the area of the cavity prepared for welding exceeds 10 sq in. / 65 square cm
Manufacturer or Vendor	Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.
Material Number	The number assigned to each item on a purchase order (also known as part

Terms	Definitions
	number, catalogue number, SAP number or material master number).
MSS	Manufacturers Standardization Society
NEB	National Energy Board
NOM	Norma Oficial Mexicana
Pressure-Containing Parts	Components designed to contain the fluid being transported in the pipeline system
Purchase order	The purchasing document used to purchase the specified item(s)
Regulatory Authority	The national and/or local regulator having jurisdiction over the facility.
Technical Agreement	The document signed by the Company and the manufacturer, which states a mutual agreement on a technical matter.
Traceability Number	A number that will be marked on the specified item(s) to allow identification of each piece. It shall consist of the letters PO, the purchase order number, the purchase order line item number, and where applicable, a numerical suffix. The numerical suffix is only required when more than one piece is supplied for the same item number on the same purchase order.
Welding Procedure	The Welding Procedure Specification, Procedure Qualification Record, and all associated non-destructive and destructive test data

PURPOSE

This Specification outlines the requirements for the materials, qualification, manufacture, testing and inspection of carbon steel valves for gas service.

SCOPE/APPLICABILITY

This Specification applies to carbon steel ball, check, gate and plug valves intended for installation in the Company's non-sour natural gas onshore pipeline systems in Canada, the United States (U.S.), and Mexico.

This Specification applies to carbon steel valves with a nominal diameter of 406.4 mm (NPS 16) and larger with a pressure class of PN 20 (ASME 150) and higher. At the Company's discretion, this Specification may be applied in whole or in part to valve sizes not specifically addressed in this Specification.

This Specification is to be used in conjunction with API Specification 6D, latest revision, and covers additional requirements to those specified in API 6D, CSA Z245.15, latest revision, and any amendment, supplement or errata issued by API or CSA.

The headings and numbering in this Specification correspond to those in API 6D. Where no incremental requirements are given in this Specification, API 6D shall apply as written. If conflict exists between this Specification and the requirements in API 6D, the more stringent of the requirements shall apply.

The Responsible Engineer shall be contacted for clarification, if needed.

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GLOSSARY

ASME

American Society of Mechanical Engineers

ASTM

American Society for Testing and Material

Bi-directional seats

A seat design where each seat must seal in both directions at all pressures, up to the rated pressure. This feature is sometimes referred to as “double piston effect”.

Bolting

Bolts, studs, cap screws and nuts.

Certificate of compliance

A document that states that the product was manufactured, sampled, tested and inspected in accordance with the applicable specification and the purchase order, and was found to have met such requirements. Bolting and pressure containing parts smaller than 60.3 mm (NPS 2) shall be furnished with a certificate of compliance or Material test report (MTR). MTRs shall be supplied for components 60.3 mm (NPS 2) and larger.

CFR

Code of Federal Regulations

Company or Purchaser

TransCanada PipeLines Limited, its corporate affiliate, or its agent.

CSA

Canadian Standards Association

Double block and bleed

A valve with two seating surfaces that, in the closed and open position, provides a seal against pressure from both ends of the valve with a means of venting/bleeding the cavity between the seating surfaces. The body cavity must be capable of being bled down to atmospheric pressure when the valve is in the fully open and fully closed positions.

Note:

This supersedes the definition in API 6D Para. 3.1.10.

Double isolation and bleed valve (DIB)

A valve with two bi-directional seating surfaces that, in the closed and open position, provides a seal against pressure from both ends of the valve and from the body cavity of the valve, and a means of venting/bleeding the pressure between the seating surfaces. This design is also referred to in API 6D as "DIB-1".

DOT

United States Department of Transportation

Equipment component

A pressure containing part used in the manufacture of a specific piece of equipment (i.e., measurement devices, control valves, pressure relief valves and regulators, etc.).

Heat treatment

One or more of the following methods:

- stress relieving
- normalizing
- normalizing and tempering
- quenching and tempering

ISO

International Organization for Standardization

Major weld repair

One or more of the following in the parent metal of a casting:

- a weld repair that is made to correct leakage
- when the depth of the cavity prepared for welding exceeds 20% of the actual wall thickness or 25.4mm (1 in.), whichever is smaller
- when the area of the cavity prepared for welding exceeds 64.52 sq. cm (10 sq. in.)

Manufacturer or Vendor

Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.

Material number

The number assigned to each item on a purchase order (also known as part number, catalogue number, SAP number or material master).

MSS

Manufacturer Standardization Society

NEB

National Energy Board

NOM

Norma Oficial Mexicana

Pressure-containing parts

Components designed to contain the fluid being transported in the pipeline system.

Purchase order

The purchasing document used to purchase the specified item(s).

Regulatory Authority

The national and/or local regulator having jurisdiction over the facility.

Technical Agreement

The document signed by the Company and the Manufacturer that states a mutual agreement on a technical matter.

Traceability number

A number that will be marked on the specified item(s) to allow identification of each piece. It shall consist of the letters PO, the purchase order number, the purchase order line item number, and where applicable, a numerical suffix. The numerical suffix is only required when more than one piece is supplied for the same item number on the same purchase order.

Welding Procedure

The Welding Procedure Specification, Procedure Qualification Record and all associated non-destructive and destructive test data.

1 SCOPE

1.1 General

1.1.1 Valves purchased for the U.S. and Mexico shall be certified as API. Valves purchased for Canada shall be certified as CSA and may be dual-certified as both API and CSA. Certification shall consist of a Manufacturer-issued certificate of compliance.

1.1.2 Valves supplied according to this Specification shall comply with the applicable technical agreement and meet any additional requirements in the request for quote and/or purchase order description.

1.3 Conformance with Specification

1.3.1 The Manufacturer shall have a documented Quality Program that is registered with an independent registrar.

1.5 Notch Toughness

1.5.1 All pressure containing components in valves shall have proven notch toughness properties at the minimum design metal temperature (MDMT) specified on the request for quote and/or purchase order.

1.6 Inspection and Test Plan (ITP)

1.6.1 Unless otherwise stated on the purchase order, the Manufacturer shall prepare and submit an inspection and test plan (ITP) conforming to the requirements of this Specification. The ITP shall list the applicable manufacturing procedures to be applied, inspection points and requirements, and the applicable acceptance criteria. The ITP requires approval by the Company prior to the commencement of manufacturing.

2 NORMATIVE REFERENCES

2.1 The Specifications and Standards listed in Section 16 shall apply in addition to those listed in API 6D.

4 VALVE TYPES AND CONFIGURATIONS

4.1 Valve Types

4.1.1 Gate Valves

4.1.1.1 Gate valves shall be of the through conduit type (round-port full-bore, slab or expanding) as specified in the request for quote and/or purchase order description.

4.1.1.2 Gate valves shall be rising stem and include a body drain valve at or near the bottom of the valve body.

4.1.1.3 Slab gate valves shall be bolted bonnet, double block and bleed, with upstream self-relieving seats. Seats shall be equipped with soft seat inserts and the seat rings shall be field removable/replaceable.

4.1.1.4 Through conduit gate valves shall have a secondary seat sealing system capable of correcting leaks at the rated working pressure of the valve.

4.1.1.5 All gate valves shall have a secondary stem sealing system capable of correcting leaks at the rated working pressure of the valve. The stem seal shall be of a type that can be hydraulically energized, such as a stacked chevron, U-cup style or other multi-component seals approved by the Company. Mechanically energized seals are also permitted.

4.1.1.6 Primary stem seal leak indicator fittings (i.e., tattletale fittings) are not permitted. Taps used for this purpose shall be sealed with a solid pipe plug.

4.1.2 Lubricated and Non-Lubricated Plug Valves

4.1.2.1 Plug valves shall be lubricated, pressure balanced and inverted taper. The lubricant used shall resist dissolving, gumming or chemical change under the service conditions specified.

4.1.2.2 Plug valves shall be manufactured with a secondary stem sealant system capable of correcting leaks at the rated working pressure of the valve. A sealant system that energizes the stem packing shall be acceptable.

4.1.2.3 Plug valves must be suitable for installation with the valve stems positioned either vertically or horizontally.

4.1.3 Ball Valves

4.1.3.1 Ball valves shall be either a full opening or reduced opening configuration, as specified on the request for quote and/or purchase order.

4.1.3.2 Ball valves shall be double isolation and bleed with two bi-directional seats (i.e., DIB-1).

4.1.3.3 Ball valves shall have a secondary seat and stem sealing system capable of correcting leaks at the rated working pressure of the valve. Primary stem seal leak indicator fittings (i.e. tattletale fittings) are not permitted. Taps used for this purpose shall be sealed with a solid pipe plug.

4.1.3.4 Ball valves must be suitable for installation with the valve stems positioned from vertical up to horizontal.

4.1.3.5 The body cavity must be capable of being bled down to atmospheric pressure when the valve is in the fully opened or closed position.

4.1.4 Check Valves

4.1.4.1 Check valves shall be regular swing type, full-opening swing type, or axial flow as specified in the request for quote and/or purchase order description.

4.1.4.2 Swing type check valves shall be equipped with a vent fitting to safely enable depressurization of the valve downstream of the clapper.

4.1.4.3 Check valves shall be designed and manufactured so that, when installed, the valves are in the closed position when at rest.

5 DESIGN

5.2 Pressure and Temperature Rating

5.2.1 For valves certified as CSA only, the pressure-temperature ratings in CSA shall apply. API valves shall comply with the pressure-temperature rating requirements of API 6D. Dual-certified valves shall comply with the pressure-temperature rating requirements of CSA for valves installed in Canada, and shall comply with the pressure temperature rating requirements of API 6D for valves installed in the U.S. or Mexico.

5.2.2 The ratings specified in Clause 5.2.1 of this Specification shall not apply to non-metallic resilient sealing or plastic sealing materials. Such materials shall be capable of withstanding the rated pressure over the temperature range specified by the Company.

5.5 Valve Operation

5.5.1 The data as listed in Clause 5.5 of API 6D shall be provided for all valves at the time of quotation except that the flow coefficient is not required for full-opening valves.

5.7 Valve Ends

5.7.1 Flanged Ends

5.7.1.1 General

5.7.1.1.1 Flanges for pressure classes PN 150 (ASME 900) and lower shall be raised face unless otherwise specified. Flanges in accordance with the requirements of CSA Standard Z245.12 shall also be acceptable.

5.7.1.1.2 End flanges shall be weld neck or integrally cast or forged flanges, provided that the design stresses are no greater than in an equivalent weld neck flange and that the flange dimensions necessary for fit-up (e.g., bolt circle diameter, bolt hole size) comply with the requirements of this Specification.

5.7.2 Welding Ends

5.7.2.1 If pipe pups are required, Engineering shall be engaged for welding ends with pipe pups (length, wall thickness and grade of pups, and wall thickness/grade of associated piping to be discussed between the Company and the Manufacturer).

5.7.2.2 The weld end of the valve shall meet the calculated inside diameter based on the specified matching pipe diameter and thickness ± 1.0 mm (± 0.04 in.). The weld end may be back beveled to meet the inside diameter requirement.

5.7.2.3 For 457 mm (NPS 18) or smaller valves, the minimum acceptable wall thickness at the weld bevel shall be 87.5% of t_D. For valves larger than 457 mm (NPS 18), the minimum acceptable wall thickness at the weld bevel shall be 92% of t_D.

Note:

t_D is the design wall thickness at the weld bevel.

5.7.2.4 The weld end of the valve shall meet the following requirements:

$$t_D \leq 1.5\ t$$

$$S_1 \leq 1.5\ S_2$$

Where:

t = specified wall thickness of matching pipe (mm/in.)

t_D = design thickness of the weld end (mm/in.)

S_1 = specified minimum yield strength of pipe (kPa/ psi)

S_2 = specified minimum yield strength of valve end (kPa/ psi)

5.8 Valve Cavity Pressure Relief

5.8.1 Valve body cavity pressure relief devices that relieve to atmosphere are prohibited.

5.9 Drains

5.9.1 For valves other than check and plug valves, at least one drain connection shall be supplied on the bottom portion. On below ground valves, connections to the valve body shall be in accordance with Clause 5.24 of this Specification.

5.10 Injection Points

5.10.1 The seat and stem sealant fittings shall be the “Flow Wolf” from Sealweld Corporation Ltd., or other Company-approved products with a one-piece body design and a threaded cage. The fitting's external thread shall be standard NPT.

5.10.2 The seat lubricating port shall be protected by a ball check device independent of the lubricating fitting to provide for safe removal or replacement of the fitting when a valve is under line pressure conditions. The ball check shall be “Flow Wolf” from Sealweld Corp., unless otherwise agreed.

5.10.3 The number and location of the seat fittings shall provide proper distribution and sufficient deposition of the sealant.

5.11 Drain, Vent and Sealant Lines

5.11.1 Drain valves for aboveground valves shall be lockable full port FNPT X FNPT ball valves with a minimum rating as shown in Table 5-2, attached to the line valve with a schedule 160 pipe nipple and plugged with a solid pipe plug. Ball valves shall be the same make/model as specified in Table 5-3 of this Specification, unless otherwise agreed. Where two or more drain or vent taps are supplied on the valve, one shall be equipped with the previously described ball valve and the remaining taps shall each be solid with a solid pipe plug, unless otherwise specified in the purchase order or datasheet. The size of the drain connections shall be in accordance with the requirements of Clause 5.11.4 of this Specification.

5.11.2 On below ground valves, the requirements of Clause 5.24 of this Specification shall be incorporated.

5.11.3 Drain piping shall be sized as per Table 5-1, except for swing check valves, which require that the drain only be 21.3 mm (NPS ½).

5.11.4 Sealant extension lines and fittings shall be 21.3 mm (NPS ½) and the stem sealant line shall be identified with a tag.

Table 5-1: Minimum Body Drain Piping Size by Valve Size

Valve Size	Minimum Body Drain Piping Size
610 mm (NPS 24) and smaller	33.4 mm (NPS 1)
Larger than 610 mm (NPS 24)	48.3 mm (NPS 1 ½)

5.13 Handwheels and Wrenches – Levers

5.13.1 Where handwheels are supplied, they shall turn clockwise to close the valve. The open and closed positions shall be labeled. An arrow to indicate the position shall be supplied by the Manufacturer.

5.14 Locking Provision

5.14.1 Manually operated valves shall be supplied with locking devices.

5.16 Position Indicators

5.16.1 All valves supplied with manual actuation (e.g., gearboxes) shall be furnished with a position indicator, clearly indicating full open and closed position of the obturator.

5.18 Actuator, Operators and Stem Extensions

5.18.6 A pressure relieving device (or spring-loaded vent) with a weatherproof cover shall be provided in a ½ in. NPT minimum size opening located approximately 150 mm (6 in.) below the top of the extension housing. The design shall be accepted in writing by the Company.

5.18.7 The inside of the valve yoke, the inside of the extension housing and the outside of the torque tube shall be cleaned free of mill scale and treated with a rust inhibitor.

5.18.8 The mounting flange joining the stem extension to the valve stem shall be furnished with a gasket or O-ring designed to prevent water from entering the joint between the stem and the extension.

5.18.9 Installation instructions for mounting the stem extensions shall be provided by the Manufacturer to the Company. The instructions shall include provisions for installing the extension during valve assembly fabrication. This shall include installation with the stem in the horizontal position. This submittal shall form part of the pre-production documentation requirements.

5.19 Lifting

5.19.1 Lifting lugs shall be designed to lift at least 1.5 times the nominal weight of the valve to withstand stresses from lifting the valve and the expected weight of a power actuator. Lifting lugs fabricated by cutting shall have the cut surfaces ground or machined to remove possible stress concentrators.

5.20 Drive Trains

5.20.4 Valve stem keys and gear set input shaft keys shall be secured in the keyway by mechanical means.

5.24 Ancillary Connections

5.24.1 Sealant injection connections to the valve body shall consist of a forged extension piece one size larger than the applicable piping and with a thickness of at least XXS. The extension piece shall be welded to the valve body using a full penetration or socket weld. Socket weld dimensions shall comply with ASME B16.11. The end of the extension piece shall have a female threaded connection fitted with a solid hex plug. The ancillary connection shall exit perpendicular to the extension piece and shall be a female threaded connection (see Figure 5-1 of this Specification).

5.24.2 Drain connections to the valve body shall be as described in Clause 5.24.1 of this Specification, except that the end of the extension piece may be solid (i.e., no female thread or hex plug required).

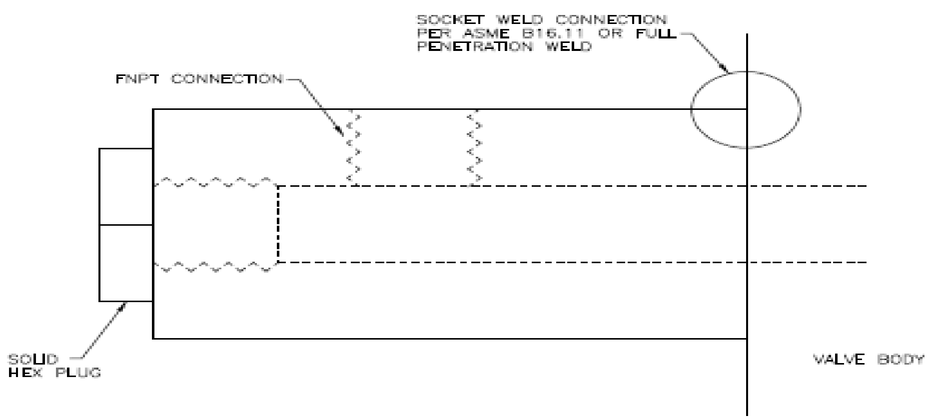

Figure 5-1: Ancillary Connections

5.25 Ancillary Piping (Sealant, Vent and Drain Piping)

5.25.1 Where necessary, ancillary piping shall be extended to a convenient and accessible location. Ancillary piping shall be capable of withstanding the maximum rated pressure at the minimum design temperature. The sealant, vent and drain pipe shall be ASTM A106 seamless pipe at a minimum. The schedule and pressure rating of the piping shall be as shown in Table 5-2.

Table 5-2: Schedule and Pressure Rating of Ancillary Piping and Valves

	PN 100 (ASME 600) and lower		PN 150 (ASME 900)		PN 250 (ASME 1500)	
	Sealant Lines	Drain Lines	Sealant Lines	Drain Lines	Sealant Lines	Drain Lines
Pipe	Schedule 160	Schedule 80	Schedule 160	Schedule 80	Schedule 160	Schedule 160
Threaded Nipples	Schedule 160	Schedule 160	Schedule 160	Schedule 160	Schedule 160	Schedule 160
Fittings	Class 6000 minimum rating	Class 3000 minimum rating	Class 6000 minimum rating	Class 6000 minimum rating	Class 6000 minimum rating	Class 6000 minimum rating
Valves	N/A	ASME 900 or 3000# WOG minimum rating	N/A	ASME 900 or 3000# WOG minimum rating	N/A	Class 5000 minimum rating

5.25.2 Except as permitted in Clauses 5.11.1, 5.25.1 and 5.25.3 of this Specification, ancillary piping connections shall be socket welded.

5.25.3 Valves for ancillary piping for belowground valves shall be lockable full port SW X FNPT ball valves with a minimum rating as shown in Table 5-2. Preferred valves shall be as shown in Table 5-3 and the use of any other ancillary valves shall be subject to the written acceptance of the Company. The valves shall be oriented with the run vertical/stem horizontal and shall have a 90-degree forged steel threaded elbow installed on the downstream end of the valve. A 12.7 mm (½ in.) NPT stainless steel threaded body vent fitting and carbon steel reducing bushing, if applicable, shall be installed downstream of the elbow.

Table 5-3: Preferred Brands for Ancillary Valves

Brand	Model #
Nutron	T3
WKM	310C
Energy Valves	Series 3000
Schuck	Type G
JAG	T3
Guide Valve Limited	VCI 201F

5.25.4 Threaded connections shall not be seal welded unless written approval is obtained from the Company.

5.25.5 Extended sealant lines attached to the valve at the time of shipment shall be filled with Sealweld Equilube 80, Sealweld Winterlube 7030, Valtex 80, Valtex 750, or an equivalent accepted in writing by the Company. Stem sealant lines shall be permanently identified as such so they are readily distinguishable from seat sealant lines.

5.25.6 Ancillary piping shall be adequately supported and protected from damage during transportation, installation and service.

5.25.7 Drain lines shall be permanently identified as to their specific function.

5.25.8 Any valve body cavity vent ports shall be sealed with a solid threaded plug.

6 MATERIALS

6.1 Material Specification

6.1.1 All materials for pressure-containing parts other than bolting shall be approved by the Company and documented in the technical agreement signed by the Company and the Manufacturer.

6.1.2 Lubricating grease used in all gear sets shall be suitable for effective operation at -45°C (-49°F) unless a different temperature is specified on the request for quote and/or purchase order.

6.1.3 Unless otherwise permitted by the Company, ball, gate and check valves shall have non-metallic resilient seat inserts suitable for natural gas service.

6.3 Service Compatibility

6.3.1 Non-metallic materials shall be suitable for low temperature applications, but may have a glass transition temperature lower than -45°C (-49°F) unless a different temperature is specified on the request for quote and/or purchase order.

6.6 Toughness Test Requirements

6.6.1 All carbon and low-alloy steels for pressure-containing parts in valves shall be impact tested using the Charpy V-notch technique at the temperature specified on the request for quote and/or purchase order. It shall be permissible to conduct the tests at a lower temperature than the one specified.

Note:

Steels such as the AISI 4100 series are not considered to be low alloy.

6.6.2 All testing shall be conducted in accordance with the requirements of ASTM A370.

6.8 Sour Service

6.8.1 This Specification has not been written for the purchasing of valves for sour service. It applies to sweet natural gas service only.

7 WELDING

7.2 Welding Procedure and Welder/Welding Operator Qualifications

7.2.1 Welding, including repair welding, of pressure-containing and pressure-controlling parts shall be performed in accordance with procedures qualified to ASME Section IX or other Company-approved Industry Standards.

7.2.2 Welding procedures for the following welds shall be submitted for review and written acceptance by the Company prior to manufacture, or shall be documented in the Technical Agreement:

a) Pressure-containing fabrication welds including valve to pup welds.

b) Weld overlays and weld build-ups.

c) Weld repairs to the welds defined in (a) and (b).

d) Weld repairs to pressure-containing cast components.

Note:

QW-200.4 of ASME Section IX requires that the deposited weld metal of each process or procedure be included in the tension, bend and Charpy specimens.

Where pressure-containing cast components are obtained from a sub-vendor, the valve Manufacturer shall be responsible for obtaining the required weld repair procedures for submission to the Company.

7.3 Impact Testing

7.3.1 The welding procedure shall include impact test results for tests conducted in the weld and heat affected zone at a temperature of -45°C (-49°F) or lower, unless a different temperature is specified on the request for quote and/or purchase order.

7.5 Repair

7.5.1 Repair of Defects in Pressure Containing Castings

7.5.1.1 All repairs by welding shall be carried out using welders and welding procedures qualified in accordance with the requirements of Clause 7.2 of API 6D.

7.5.1.2 Defects shall be removed by suitable mechanical, thermal cutting or thermal gouging methods with the resultant cavity being thoroughly cleaned and suitably prepared for inspection by magnetic particle or liquid penetrant methods. This inspection shall be used to verify the complete removal of the defect.

7.5.1.3 When defects are removed by mechanical methods and where the depth of the cavity is equal to or less than 10 percent of the nominal wall thickness at a specific location, the excavated area shall either be blended uniformly into the surrounding surface or filled by welding.

7.5.1.4 When defects are removed by thermal cutting or gouging methods or when the depth of the cavity is greater than 10 percent of the nominal wall thickness at a specific location, the excavated area shall be filled by welding. After repair, the surface shall be blended uniformly into the surrounding surface.

7.5.1.6 All major weld repairs to castings that are pressure-containing parts shall be heat-treated.

8 QUALITY CONTROL

8.1 NDE Requirements

8.1.1 Extent of Inspection

8.1.1.1 Welds and pressure-containing parts shall be non-destructively inspected as specified in Clauses 8.1.2 to 8.1.4, inclusive, of this Specification.

8.1.2 Casting Inspection

8.1.2.1 All pressure-containing castings shall be fully inspected by magnetic particle in accordance with the requirements of Annex G, Clause G.7 of API 6D.

8.1.2.2 Critical sections of pressure-containing cast components, as defined by the Manufacturer and as accepted in writing by the Company, shall be inspected by film radiography in accordance with the requirements of Annex G, Clause G.2 of API 6D or by ultrasonic testing in accordance to the requirements of Annex G, Clause G.4 of API 6D. Weld repairs to critical sections shall be inspected with the same method that detected the defect.

8.1.2.3 The buttwelding ends of all cast valves shall be inspected by film radiography in accordance with the requirements of Annex G, Clause G.3 of API 6D.

8.1.3 Weld Inspection

8.1.3.1 The following welds shall be radiographically and/or ultrasonically inspected for their full volume in accordance with the requirements of Clause 8.1.4.1 of this Specification:

a) Pressure-containing fabrication welds 60.3 mm (NPS 2) or larger.

b) Weld repairs to the welds defined in (a).

c) Except as allowed by Clause 8.1.3.2 (d) of this Specification, major weld repairs to pressure-containing parts.

8.1.3.2 The following welds shall be inspected using magnetic particle or liquid penetrant techniques and visual inspection in accordance with the requirements of Clause 8.1.4.1 of this Specification:

a) Welds joining a pressure-containing part that is smaller than 60.3 mm (NPS 2) to another pressure-containing part.

b) Welds joining a non-pressure-containing part to a pressure-containing part (e.g., lifting lugs, reinforcing plates, anchor pins).

c) Weld overlays and weld build-ups.

d) Major weld repairs to pressure-containing parts that only exceed the limits defined in the Glossary of this Specification and that have not been inspected in accordance with the requirements of Clause 8.1.3.1 (c) of this Specification, provided that the weld cavity, root pass and completed weld are inspected.

8.1.4 Acceptance Standards

8.1.4.1 Non-destructive inspection conducted in accordance with the requirements of Clause 8.1.3 of this Specification shall meet the applicable requirements of Annex G in API 6D.

8.1.5 Radiographs

8.1.5.1 All radiographs shall be identified and shall be made available to the Company representative, on request.

9 PRESSURE TESTING

9.1 General

9.1.1 The seat tests and the last portion of the shell test shall be conducted in the presence of the Company representative, unless otherwise agreed in writing by the Company.

9.1.2 The written test procedures shall be submitted for review and written acceptance by the Company prior to use, or shall be documented in the Technical Agreement.

9.1.3 Operational/functional tests shall comply with Annex H.6 of API 6D.

9.3 Hydrostatic Shell Test

9.3.1 The test duration shall be in accordance with the requirements of Table 9-1.

Table 9-1: Minimum Duration of Hydrostatic Shell Tests

Nominal Valve Size	Minimum Test Duration (minutes)	
	Shell Test – Cast Body	Shell Test – Fabricated or Wrought Body
Up to 457 mm (NPS 18)	120	30
508 mm (NPS 20) to 914 mm (NPS 36) incl.	240	60
Larger than 914 mm (NPS 36)	240	120
Note: Test duration of fabricated valves, which include castings as pressure containing components, shall be as shown for cast body valves.		

9.3.2 The test pressure, test duration and temperature of the pressure-test liquid shall be continuously recorded.

9.4 Hydrostatic Seat Test

9.4.2 Test Pressure and Duration

9.4.2.1 The test duration shall be in accordance with the requirements of Table 9-2.

Table 9-2: Minimum Duration of Seat Tests

Nominal Valve Size	Minimum Test Duration (minutes)
Up to 457 mm (NPS 18)	5
508 mm (NPS 20) to 914 mm (NPS 36) incl.	10
Larger than 914 mm (NPS 36)	15

9.4.3 Acceptance Criteria

9.4.3.1 The maximum permissible leakage rate for both hydrostatic and low pressure gas seat tests shall be ISO 5208 Rate A (no visually detectable leakage), except for metal seated check valves. Metal seated axial flow check valves shall not exceed ISO 5208 Rate D and metal-seated dual plate check valves shall not exceed 50 percent of that allowed by API 598.

9.4.4 Seat Test Procedures for Block Valves

9.4.4.3 Additional Seat Testing

9.4.4.3.1 Valves designed as double block and bleed (DBB) or double isolation and bleed (DIB-1) shall be subjected to additional seat testing as specified in Clause 9.4.4.3 of API 6D.

9.4.4.3.2 For all valves other than check valves, the valve shall be fully opened at the end of each seat test to demonstrate the satisfactory mechanical operation of the valve. The pressure on the seat when the valve is opened shall not be less than the maximum cold working pressure given in the applicable table of ASME B16.34.

9.4.4.6 Alternative Seat Test

9.4.4.6.1 At the Manufacturer’s option, the alternative test described in API 6D may be conducted.

9.4.4.7 Low-pressure Gas Seat Testing

9.4.4.7.1 Type II low-pressure gas seat testing as specified in API 6D, Annex H.3 shall be conducted. Test duration shall be as specified in API 6D.

9.7 Draining

9.7.1 After successful completion of all pressure tests one of the lubricants specified in Clause 5.25.5 of this Specification shall be injected via the seat lubrication fitting in sufficient quantity to expel any test fluid that may have entered the lubricant passageways and seat ring channels.

9.7.2 If it is not possible to remove all test liquid from the body cavity prior to shipment, it shall be filled with a sufficient quantity of propylene glycol to prevent freezing of any remaining test liquid. The internal surfaces are to be dried with compressed air treated with rust inhibitor to provide a protective film.

9.7.3 Any ancillary valves shall be completely drained of water.

11 MARKING

11.1 For API certified valves, in addition to the markings required by Table 7 of API 6D, the following markings shall be added. Markings required by API 6D shall be in U.S. customary units (i.e., imperial units):

a) “API 6D” shall be stamped on the nameplate.

b) The API monogram shall be stamped on the nameplate, when applicable.

c) The traceability number shall be stamped on the nameplate and the body.

11.2 For CSA certified valves, markings as required by Clause 14.1 of CSA Z245.15 and the traceability number shall be included on the nameplate. All marking on this nameplate shall be in metric units.

11.3 For dual-certified valves, two nameplates (i.e., API and CSA) shall be provided.

11.4 Two sets of the applicable nameplate(s) shall be provided. One set shall be installed on the valve and the second set shall be attached with a wire to an appropriate location on the valve.

12 PREPARATION FOR SHIPMENT

12.1 Unless otherwise specified on the request for quote and/or purchase order, valve stem extensions shall be removed for shipping.

12.2 Unless otherwise agreed by the Company, valves shall be given a factory standard primer protective coating for protection during shipping.

12.3 Threaded and machined surfaces subject to corrosion shall be well protected by grease or other suitable inhibitors that will remain in place and will not deteriorate under atmospheric conditions before or during shipment.

12.4 The Manufacturer shall be responsible for suitably packaging the valve and all accessories to ensure protection from mechanical damage, moisture and debris during shipping and handling. All packaging and temporary closures shall be securely fastened. Welded attachments are prohibited. Flanged faces may be primed but not painted. End caps shall be installed before shipping.

12.5 Loose parts shall not be shipped inside any valve.

13 DOCUMENTATION

13.1 The documentation required by Clauses 13.2 to 13.10 of this Specification shall be submitted to the Company.

13.2 Except for bolting, the Manufacturer shall furnish a report of the heat analysis for each pressure-containing part 60.3 mm (NPS 2) and larger. A certificate of compliance shall be furnished for bolting for pressure-containing parts smaller than 60.3 mm (NPS 2).

13.3 The Manufacturer shall furnish a report of the product or heat analysis, as well as the carbon equivalent for the field weld ends.

13.4 Except for bolting, the Manufacturer shall furnish a report of the tensile tests and Charpy tests for each pressure-containing part 60.3 mm (NPS 2) and larger. A certificate of compliance shall be furnished for bolting for pressure-containing parts. Reports of Charpy V-notch tests shall include the following:

a) the test specimen size

b) the test specimen orientation

c) the test temperature

d) the actual test results for each test specimen

13.5 A permanent record of the shell test pressure, test duration and temperature reading experienced during the test period shall be recorded on a test chart and a copy shall be provided to the Company. A certified test report for the hydrostatic seat tests, the air seat tests and the operational tests shall be made and a copy shall be provided to the Company. The test charts and certified test reports shall be identified with the following:

a) name of valve Manufacturer

b) valve Manufacturer’s shop order number

c) Company’s purchase order number

d) valve serial number and model or figure number

e) date of the test

f) signature and job title of the Manufacturer’s representative who witnessed the test

g) brand, serial number and calibration certificate of recording gauge

13.6 A written record of all non-destructive inspection results required by Clause 8.1 of this Specification shall be prepared and certified by the Manufacturer for submission to the Company.

13.7 The Manufacturer shall include a copy of the Company-accepted drawing in the documentation package.

13.8 The reports and test certificates shall contain the following additional information:

a) Confirmation that the valves have been manufactured in accordance with the requirements of this Specification and the latest signed Technical Agreement.

b) Make, model and serial number of manual gear set, if supplied with the valve.

13.9 A photocopy or “rubbing” of both nameplates on the valve.

13.10 The Manufacturer shall supply to the Company, prior to shipping the valve, reports and test certificates correlated to the valve serial number, the traceability number and the material number. The reports and test certificates shall be in a format acceptable to the Company.

15 PREPRODUCTION AND QUALIFICATION REQUIREMENTS

15.1 The Company shall supply the Manufacturer with a request for quote and, where applicable, a purchase order describing the operating conditions for which the valves are intended.

15.2 The Manufacturer shall supply the Company, at the time of quotation, any exceptions or alternatives to this Specification. Items covered by technical agreements need not be addressed at the time of quotation, as the technical agreements apply to each order.

15.3 As part of the qualification procedure, the Manufacturer shall submit the following documents and shall have received written acceptance of such from the Company:

a) The type of documented quality program being used and a copy of the registration certificate (see Clause 1.3.1).

b) Inspection and test plan (see Clause 1.6).

c) Pressure-relieving devices (see Clause 5.18.6).

d) Installation instruction for mounting extended stems, including vertical and horizontal installation (see Clause 5.18.9).

e) Stem extension and ancillary piping details, including bill of materials, attachment of ancillary piping to valve, pressure class and pipe schedule as applicable to pressure containing parts (see Clauses 5.24 and 5.25).

f) Alternative ancillary valves (see Clauses 5.10.2 and 5.25.3).

g) Materials for pressure-containing parts (see Clause 6.1.1).

h) Welding procedures (see Clause 7.2.2).

i) Definition of critical sections on castings (see Clause 8.1.2.2).

j) Ultrasonic inspection procedures for critical sections on castings, where applicable (see Clause 8.1.2.2).

k) Pressure test procedure (see Clause 9.1.2).

The Manufacturer shall provide sufficient notification informing the Company in writing of any changes to the above documents and shall obtain the written acceptance for such changes.

15.4 Drawings that include the following details shall be submitted by the Manufacturer for written acceptance by the Company. The drawings shall be resubmitted only when changes are made to them.

a) Outline dimensions.

b) For valves containing a field weld end, the weld end dimensions.

c) For valves containing welds defined in Clause 7.2.2 of this Specification, the thickness of the joint at the weld bevel. (This information may be shown as a note or sketch within the drawing.)

d) Welding procedure to be used for welds defined in Clause 7.2.2 of this Specification.

e) Company SAP material number and Manufacturer model number.

f) Bill of Materials for pressure-containing parts and lifting lugs.

g) Minimum design temperature.

h) Applicable Company Specification, revision number and revision date.

i) Valve operator mounting details.

j) The size of the drain connections.

k) The size of the body vents.

l) Drawing number and revision number, along with revision description, if applicable.

16 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are listed in Table 16-1, Table 16-2 and Table 16-3. Use the latest document revision, unless otherwise approved by TransCanada.

Table 16-1: Regulatory References

Organization/Document No.	Title
National Energy Board (NEB)	SOR/99-294, *National Energy Board Onshore Pipeline Regulations (NEB OPR)*
NOM-007-SECRE	*Transporte de Gas Natural*
U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) Code of Federal Regulations (CFR)	Title 49 Part 192, *Transportation of Natural Gas and Other Gas by Pipeline: Minimum Safety Standards*
Various	Other applicable federal, provincial and territorial safety acts and regulations by the authority having jurisdiction

Table 16-2: External Industry References

Organization/Document No.	Title
American Society for Testing and Material (ASTM)	A106, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*
	E186, *Reference Radiographs for Steel Castings from 2" up to 4.5" in Thickness*
	E280, *Reference Radiographs for Steel Castings from 4.5" through 12"*
	E446, *Reference Radiographs for Steel Castings up to 2" in Thickness*
American Society of Mechanical Engineers (ASME)	B16.11, *Forged Fittings, Socket-Welding and Threaded*
Canadian Standards Association (CSA)	Z245.12, *Steel Flanges*
	Z245.15, *Steel Valves*
	Z662, *Oil and Gas Pipeline Systems*
International Organization of Standardization (ISO)	9001, *Quality Management Systems – Requirements*

Table 16-3: Internal References

Document No.	Title
For this Specification, there are no specific Internal references.	

17 DOCUMENT HISTORY

Rev.		
01	**Description**	**Effective Date**
	Revised document developed as part of Columbia Pipeline Integration.	2017-Aug-01
	Rationale Statement	**Responsible Engineer**
	This document was revised to address the following requirements: • Integration of Columbia Pipeline requirements.	Cindy Guan, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group, to integrate Columbia Pipeline requirements, and to make it more easily accessible to those who use it	Cindy Guan, P. Eng.

Rev.		
00	**Description**	**Effective Date**
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	**Responsible Engineer**
	This document was revised to address the following requirements: • Alignment with new document definitions, structure, and templates.	Cindy Guan, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group and to make it more easily accessible to those who use it.	Cindy Guan, P. Eng.

18 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
N/A	This Specification was updated and put into the new template. Changed name from TES-VALV-G to TES-MA-VALV-G following the new naming convention.

19 APPROVALS

APPROVALS		
Originator: Sandra Kleinsasser, P. Eng. Welding and Materials Engineering	Signature	June 21, 2017 Date
Reviewer: Jessica de Vries, P. Eng. Welding and Materials Engineering	Signature	June 21, 2017 Date
Reviewer: Jaclyn Brown, PE USGO Integrity Program Services	Signature	6/21/2017 Date
Responsible Engineer: Cindy Guan, P. Eng. Welding and Materials Engineering	Signature June 21, 2017 Date	PROFESSIONAL ENGINEER XINGSHENG (CINDY) GUAN ALBERTA APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, Manager Engineering Technical Governance	Signature	June 21, 2017 Date

PURPOSE

This Specification describes requirements for the manufacturing design, fabrication, inspection, qualification, and testing of gas hydraulic and gas pneumatic valve operators, and the associated devices required for the control and operation of valves.

SCOPE / APPLICABILITY

This Specification applies to gas hydraulic valve operators, gas pneumatic valve operators, and all associated control and instrumentation piping, tubing, fittings, and valves. Refer to Appendix B for an illustration of the scope of this Specification. For typical field installed components, refer to *STDS-01-VA-03-001: Power Gas Installations VOP-1 to VOP-12*.

This Specification applies to operators installed on valves of all Nominal Pipe Sizes (NPS) and pressure ratings on natural gas transmission pipelines and natural gas facilities such as launcher/receiver stations, meter stations, and compressor stations.

This Specification does not apply to operators for valves installed in sour gas service.

This Specification does not apply to operators for valves installed as part of oil or liquid pipelines and/or oil or liquid facilities.

Within this Specification, TransCanada is referred to as the Company.

Within this Specification, the following terms and definitions apply for requirements:

- Shall—expresses a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard. Shall is not a recommendation but a requirement.
- Should—expresses a strong preference, recommendation or that which is advised, but not required.
- Must—denotes a requirement of the Company, for which no deviation or variance would be granted.
- May—expresses an option or that which is permissible within the limits of the standard.
- Consider—assumes that a competent person will evaluate options to fulfill the intent of the requirement and make a documented decision supported by evidence to ensure protection of people, equipment and the environment by achieving the appropriate level of functional integrity.

Wherein the Manufacturer’s literature, governmental or regulatory requirements conflict with this Specification, the more stringent requirement shall govern.

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1 GLOSSARY

Data Sheet

Additional technical information sheets supplied by the Company to the Manufacturer specifying any details that form part of the request for quotation, purchase order, or release order.

Gas/Hydraulic Valve Operator

A gas powered hydraulic operator with high pressure natural gas directed to gas hydraulic tanks with hydraulic fluid used as the working medium.

Gas/Pneumatic Valve Operator

A gas-powered operator with high pressure natural gas (Gas Direct) or pressure regulated natural gas (VOP-100 and VOP-101) directed to pistons with natural gas used as the working medium.

Manufacturer

A Manufacturer who submits a proposal in accordance with this Specification and thereby assumes overall responsibility for the design, manufacture, testing, operation, and performance of the gas powered hydraulic and gas pneumatic operators.

NDE

Non-Destructive Examination

NPS

Nominal Pipe Size

NPT

Nominal Pipe Thread

Operator

A Valve Operator or Actuator is the mechanism that provides the motive force and mechanical connection to open or close a valve. For the purpose of this specification, the term “operator” is used as opposed to “actuator”.

Pressure Containing

Any component NPS 2 or larger in size, and all weldments, that are subject to internal gas pressure, including those components and weldments used in the fabrication of a gas/hydraulic tank or power gas storage bottle.

Special Processes

Processes where the results of such processes cannot be fully verified by subsequent inspection and testing of the product and where processing deficiencies may become apparent only after product is in use.

VOP

Valve Operator Package

2 REQUIREMENTS

2.1 General Requirements

2.1.1 The Manufacturer is responsible for ensuring special processes, such as welding, are carried out by qualified personnel. Sufficient monitoring and control of process parameters shall be in place to ensure specified requirements are met.

3 PRE-PRODUCTION REQUIREMENTS

3.1 Welding and NDE Pressure Weld

3.1.1 Prior to commencement of production, the Manufacturer shall submit, or have previously submitted, for written acceptance by the Company, procedures for welding and non-destructive examination (NDE).

3.1.2 The Manufacturer shall inform the Company in writing of any changes to the above documents.

3.2 Welding Qualifications

3.2.1 The Company shall review welding procedures for the following welds and provide written acceptance of:

- pressure-containing fabrication welds
- weld overlays and weld build-ups to pressure containing parts
- weld repairs to the welds defined above
- welds used to attach non-pressure-containing parts to pressure-containing parts

3.2.2 For the welds listed in 3.2.1 that are not heat-treated, the Manufacturer shall ensure that the welding procedure shall include at least two micro-hardness traverses across the weld, heat-affected zones, and parent metal as shown schematically below. One traverse shall be between 1 mm and 2 mm from the outside surface of the test specimen, and one traverse shall be between 1 mm and 2 mm from the inside surface of the test specimen. Each traverse shall consist of the following:

- at least one reading taken within the weld
- at least one reading on each side of the weld in the heat-affected zone
- at least one reading on each side of the weld in the parent metal

All results shall be reported.

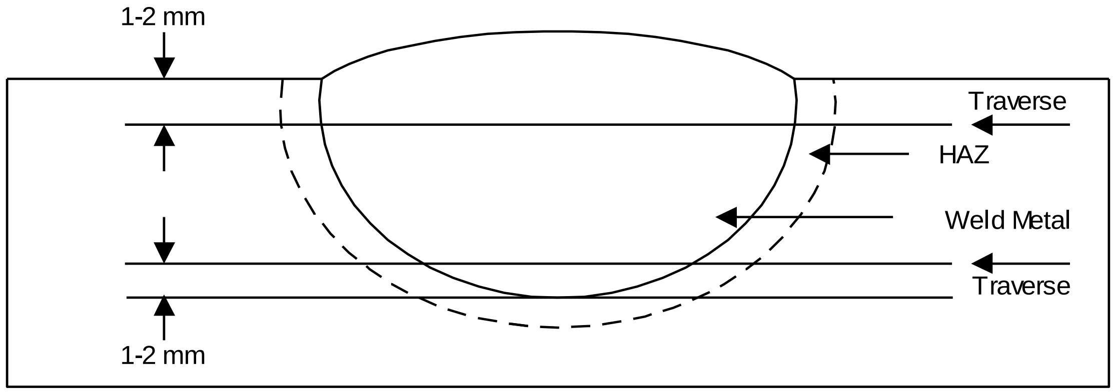


Figure 3-1: Traverses

3.2.3 The Manufacturer shall ensure that micro-hardness tests are conducted in accordance with the requirements of ASTM Standard E384.

3.2.4 The Manufacturer shall ensure that the hardness does not exceed 350 HV using a 500-gram load.

3.2.5 The Manufacturer shall ensure that evidence of written acceptance of the weld procedures are made available to the Company's representative at the time of inspection, if applicable. This evidence may be in the form of approved drawings, with the welding procedures referenced on the drawings.

3.2.6 The Manufacturer shall ensure that welds, defined in this section, are made using welders and welding procedures qualified in accordance with the requirements of *ASME Boiler and Pressure Vessel Code, Section IX*.

3.3 Standard Drawing

3.3.1 The Manufacturer shall submit, or have previously submitted, drawings for written acceptance, which shall include the following:

- outline dimensions of all operator sizes, mounting and assembly, and weights
- Bill of Materials for pressure-containing parts, including material designations
- NDE technique(s) employed, welding procedures used, design temperature, Specification number and revision date
- vent pipe design/assembly
- desiccant/filtration assembly
- control schematics and electrical wiring diagrams correlated to Valve Operator Package (VOP) numbers, as defined in section 9 or per the project-specific data sheet

3.4 Drawings for Approval

3.4.1 The Manufacturer shall supply one set of reproducible drawings, schematics, and bills of materials for Company approval.

3.4.2 The Company may waive approval drawings at their discretion, if pre-approved valve operator standard drawings, documents, schematics, and wiring diagrams are being used by the Manufacturer. Refer to section 3.3 for more information on standard drawings.

3.5 Confirmation of Order Information

3.5.1 The Manufacturer shall submit to the Company, at the time of quotation or acceptance of an order, the following information as a confirmation of order:

- purchase order specific information, including the purchase order number, material number, tag numbers, and project names
- manufacturer drawing numbers previously approved by the Company, to be used for operator fabrication and assembly
- torque and thrust capabilities at required differential pressures
- the make and model of the matching valve; and the torque or thrust requirements of that valve
- the valve and valve stem orientation
- the Valve Operator Package (VOP) number, if specified in the request for quotation
- the purchase order or data sheets
- the Company's data sheet number, if the VOP number above is not applicable
- any special requirements for operation and maintenance

4 OPERATOR PACKAGE DESIGN REQUIREMENTS

The requirements in this section apply to all operator packages, including both gas hydraulic and gas pneumatic packages.

4.1 Service Requirements

4.1.1 The Manufacturer shall ensure that the operator is suitable for use in high-pressure natural gas transmission service.

4.2 Design Codes and Standards

4.2.1 The Manufacturer shall ensure that valve operators, including the piping and pressure vessels, are designed, manufactured, inspected, and tested in accordance with the reference publications listed in this Specification.

4.3 Surface Preparation

4.3.1 The Manufacturer shall ensure that valve operators are blast-cleaned to a commercial blast finish (SSPC SP-6) or cleaner.

4.3.2 The Manufacturer shall ensure that valve operators are coated with an epoxy primer and topcoat. The topcoat colour shall be white.

4.3.3 The Manufacturer shall ensure that all normally exposed sliding stems or plungers are protected by flexible neoprene boots to prevent ice or paint build-up, corrosion, or inadvertent sand blasting.

4.4 Gate Valves (Gas Hydraulic or Gas Direct Operator)

4.4.1 The Manufacturer shall ensure that linear valve operators for gate valves incorporate mechanical position locks to allow positive positioning of the gate in any position.

4.5 Valve Operator Orientation

4.5.1 The valve position, orientation, and location (above or below ground) shall be specified on the purchase order or data sheet.

4.5.2 The Manufacturer shall ensure that the valve operators for ball and plug valves are built to allow installation on a vertical or horizontal stem orientation, as specified in the purchase order or Company data sheet.

4.5.3 The Manufacturer shall ensure that the valve operators for ball and plug valves ordered for a vertical stem orientation are built to allow installation in any 90° position around the centerline of the valve stem.

4.5.4 The Manufacturer shall ensure the valve operators are capable of functioning in the valve position specified on the purchase order or data sheet without malfunction or loss of hydraulic fluid.

4.6 Valve Operator Mounting

4.6.1 The Manufacturer shall supply all adapters and supporting hardware needed to match the operator to the top works of valves described in the purchase order or data sheet.

4.6.2 The Manufacturer shall ensure the operator yokes are keyed for keyed valves/stems. The Manufacturer shall determine and supply a shear key if one is required.

4.7 Operator End Stops

4.7.1 For rotating stems, the Manufacturer shall ensure the valve operator is equipped with externally adjustable end-of-stroke stops which shall provide a minimum of 2.5° stem rotation at each end of travel.

4.7.2 For linear stems, the Manufacturer shall ensure the valve operator is equipped with an externally adjustable end-of-stroke stop which shall provide a minimum of 1/2-inch gate adjustment at close end of travel.

4.7.3 The Manufacturer shall ensure that Operator End Stops can absorb the maximum torque or thrust output of the operator at the maximum power gas pressure.

4.7.4 The Manufacturer shall ensure that the Operator is fitted with a clearly distinguishable position indicator.

4.8 Valve Stem Loading

4.8.1 The Manufacturer shall ensure that the valve operator is designed to ensure that no side loading is imparted to the valve stem.

4.9 Power Gas Storage Tanks

4.9.1 When specified on the purchase order or data sheet, the Manufacturer shall ensure that a power gas storage bottle, with an isolating check-valve on the supply line, is incorporated on the power gas circuit to provide sufficient reserve for one valve closure at the minimum operating pressure.

4.9.2 The Manufacturer shall ensure that power gas storage tanks are designed, constructed, and tested in accordance with this Specification for a maximum design pressure of 9,930 kPa or greater, as specified in the project-specific data sheet.

4.9.3 The Manufacturer shall ensure that power gas storage tanks are provided with a drain plug, located at the bottom of the vessel.

4.9.4 The Manufacturer will determine if a CSA-approved factory sealed pressure relief valve is required on the power storage tank. The Manufacturer shall provide the relief valve, if required.

4.10 Seals

4.10.1 The Manufacturer shall ensure that dynamic, gas-wetted seals and O-rings are suitable for use with synthetic lubricants over the range -45°C to +45°C.

4.10.2 The Manufacturer shall ensure that seals withstand exposure to possible synthetic lubricant contamination in the power gas supply.

4.11 Integrally or Remote Mounted Equipment

4.11.1 The Manufacturer shall ensure that the valve operator is supplied with integrally mounted devices and components to provide a complete operating unit, to which the Company will make its electrical and gas connections (power gas and sensing lines).

4.11.2 When specified on the purchase order or data sheets, the Manufacturer shall ensure that the control devices, pumps, and tanks are mounted on a “Remote Mounted” stand.

4.12 Materials for Tubing and Instrument Fittings

4.12.1 The Manufacturer shall ensure that all tubing is bright annealed seamless stainless steel, in accordance with the requirements of *ASTM A269 Grade TP 304* or *TP 316*.

4.12.2 The Manufacturer shall ensure that all fitting material is *ASTM A182 Grade F316* stainless steel employing bite-type or compression-type flareless fittings. Fittings shall be SWAGELOK.

4.13 Power Gas Filters

4.13.1 The Manufacturer shall ensure that power gas and control gas are filtered by means of a dry-type filter that is provided as part of the operator assembly.

4.13.2 The Manufacturer shall ensure that filter elements are stainless steel, easily removed for cleaning, and shall be reusable.

4.13.3 The Manufacturer shall ensure that elements have filtration openings with dimensions that are no larger than 140 microns (0.0055 inch).

4.13.4 The Manufacturer shall ensure that the filter is equipped with a body drain.

4.14 Desiccant-Filter Package

4.14.1 The Manufacturer shall provide a standard desiccant-filter package, including a molecular sieve and a stainless steel filter (e.g., Fisher 252) in series, when requested in the data sheets or purchase order. The Manufacturer shall pre-submit the standard package to the Company for approval.

4.14.2 The Manufacturer shall ensure the desiccant-filter package is mounted on a sub-plate, which is mounted on the operator.

4.14.3 The Manufacturer shall ensure that all components in the desiccant-filter package are rated for a working pressure of 9,930 kPa or greater, as specified on the project-specific data sheet.

4.14.4 The Manufacturer shall ensure that the proper size of desiccant-filter package is supplied for the size of valve operator, based on a reduction of water content in the power gas supply from 4 lbs. H_2O/MMSCF to 1 lbs. H_2O/MMSCF.

4.14.5 The Manufacturer shall size the desiccant-filter package to provide sufficient flow to allow proper operation of the valve actuator under normal operating conditions.

4.14.6 The Manufacturer shall ensure that the stainless steel filter has filtration openings with dimensions that are no larger than 140 microns. The gas filter shall be easily removable and re-usable with a manual body drain.

4.15 Power Gas Venting

4.15.1 The Manufacturer shall ensure that at the end of valve travel, the power gas within the gas/hydraulic tanks is vented to atmosphere.

4.15.2 The Manufacturer shall supply NPS 2 power gas vent piping and install it at the top of the valve operator to allow the release of the vented gas.

4.15.3 The Manufacturer shall ensure that a provision is made to prevent weather elements or foreign objects that may cause blockage from entering the vent piping.

4.15.4 The Manufacturer shall provide an NPT drain port at the low point for the vent piping, allowing any liquids to be drained.

4.16 Test Ports

4.16.1 The Manufacturer shall ensure that pneumatic devices, subject to set point verification, calibration, and/or adjustment (e.g., line break devices, regulators), are furnished with a 1/4 inch NPT test port complete with a needle valve and a pipe plug.

4.16.2 The Manufacturer shall ensure the test can be performed with either hydraulic oil or gas, and that the hydraulic oil can be properly drained after testing if oil is used.

4.17 Enclosure

4.17.1 The Manufacturer shall ensure that the valve operator controls which enable manual operations, as defined in section 4.18, are housed and fitted with a locking door suitable for use with a standard padlock.

4.17.2 Enclosure is not required for VOP-100 and VOP-101 operators.

4.18 Operating Modes – Manual Control

4.18.1 The Manufacturer shall ensure that each valve operator is equipped with local manual control, so the valve may be opened or closed locally when power gas is available.

4.18.2 The Manufacturer shall ensure that remote automatic control signals will override the local manual control upon release of the local manual control lever.

4.18.3 The Manufacturer shall ensure that each valve operator has labels describing operating direction and identification for manual controls clearly displayed on the valve operator.

4.19 Operating Modes – Hand-Pump Control

4.19.1 The Manufacturer shall ensure that each valve operator is equipped with a hand-pump so the valve can be operated manually at the full differential pipeline pressure.

4.19.2 The Manufacturer shall ensure that the hand-pump is equipped with an open/close control lever. Setting the control lever to open or close shall enable hand-pump operation.

4.19.3 The Manufacturer shall ensure that the open/close control lever on the hand-pump provides positive indication locally that the hand-pump is in the manual mode (i.e., open or closed position). Alternately, if the lever is left in the open or closed position, it shall reset to the normal control position automatically when the local manual control is disengaged, or the remote automatic control is initiated.

4.19.4 The Manufacturer shall ensure that the hand-pump control system does not allow potentially dangerous sudden movement of the hand-pump lever when local manual control or remote automatic control is initiated.

4.19.5 A hand-pump is not required for VOP-100 and VOP-101 operators.

4.20 Lifting Ring

4.20.1 The Manufacturer shall ensure that each valve operator has lifting ring(s) attached at the top so that the entire operator, fully filled with hydraulic oil, can be lifted and installed.

4.21 Marking

4.21.1 The Manufacturer shall ensure that all marking applied to pressure containing parts are made using low stress stamps.

4.21.2 In addition to markings required by *ASME Section VIII Div. 1* and/or the Provincial Authority having Jurisdiction (e.g. ABSA), the Manufacturer shall ensure that the valve operator is marked with the following information:

- CSA electrical design classification
- design pressure
- minimum design temperature in degrees Celsius
- serial plate, which includes:
  - operator serial number
  - operator model number
  - maximum working pressure
  - purchase order number and item number
  - valve identification number / tag number
  - name of Manufacturer
  - date of manufacture (year and month)

5 GAS HYDRAULIC OPERATOR-SPECIFIC DESIGN REQUIREMENTS

The requirements in this section are specific to gas hydraulic operator packages. They are in addition to the requirements listed in section 4: Operator Package Design Requirements.

5.1 General Requirements

5.1.1 The gas/hydraulic valve operator shall operate with natural gas directed to the gas hydraulic tanks.

5.1.2 The Manufacturer shall ensure that the hydraulic fluid contained in the gas hydraulic tanks are the working medium of the operator.

5.1.3 The gas hydraulic valve operator shall operate with high-pressure natural gas or regulated gas to a pressure not exceeding the maximum working pressure of the operator.

5.2 Registration

5.2.1 The Manufacturer shall be responsible for complying with any pressure vessel registrations within the province which the valve operator is installed.

5.3 Gate Valves

5.3.1 The Manufacturer shall ensure that the hydraulic circuit includes thermal pressure relief protection to prevent damage to the operator.

5.3.2 Based on the gate valve function and service conditions, the Company will determine the need for an accumulator to be used for the prevention of temperature induced creep. If an accumulator is required, it shall be quoted by the Manufacturer at the time of order.

5.4 Gas Hydraulic Tanks

5.4.1 The Manufacturer shall ensure that the gas hydraulic tanks are designed, constructed, and tested in accordance with this Specification for a maximum design pressure of 9,930 kPa or greater, as specified in the project-specific data sheet.

5.4.2 The Manufacturer shall ensure that the tanks are supplied with the initial fill of hydraulic fluid.

5.4.3 The Manufacturer shall ensure that the gas entry port of the tank is fitted with a diffuser to prevent the power gas from foaming or churning the hydraulic fluid.

5.4.4 The Manufacturer shall ensure that the hydraulic fluid exit port on the tank is fitted with a riser so that sufficient sump volume exists in the tank to prevent contaminants or condensation from entering the operator cylinder.

5.4.5 The Manufacturer shall ensure that provisions are made to drain contaminants or condensation without removing the riser fitting.

5.4.6 The Manufacturer shall ensure that each tank has a drain plug on the bottom, which enables the hydraulic oil to be drained.

5.4.7 Prior to assembly, the Manufacturer shall ensure that the internal surfaces of the tanks are thoroughly shot blast cleaned to remove mill scale and rust.

5.5 Seals

5.5.1 Elastomer seals and control/power block components machining tolerances shall be compatible with Esso Univis HVI-13, Marinus, or other eco-friendly hydraulic oils.

5.6 Hydraulic Fluid

5.6.1 The Manufacturer shall ensure that the hydraulic fluid used is Esso Univis HVI-13, or a Company-approved equal.

6 GAS PNEUMATIC OPERATOR-SPECIFIC DESIGN REQUIREMENTS

The requirements in this section are specific to gas pneumatic operator packages. They are in addition to the requirements listed in section 4: Operator Package Design Requirements.

6.1 General Requirements

6.1.1 The valve operator shall operate with high-pressure natural gas or regulated gas to a pressure not exceeding the maximum working pressure of the operator.

6.2 Valve Operator Mounting

6.2.1 The Manufacturer shall provide wrench override adaptors for VOP-100 and VOP-101.

7 ENGINEERING REQUIREMENTS

7.1 Valve Data

7.1.1 Where insufficient data is available from the valve Manufacturer, the Manufacturer may utilize data available for comparable valves. Where such assumed data is used, the Manufacturer shall obtain the Company's prior written approval.

7.2 Normal Operating Conditions

7.2.1 The valve operator will operate under non-corrosive gas service. Valve operator materials shall be suitable for exposure to sweet natural gas that may contain by-products of processing and treating natural gas.

7.2.2 The Manufacturer shall ensure that the valve operator is designed to operate at ambient temperatures of -45°C to +45°C.

7.3 Power Gas Supply

7.3.1 The valve operator power gas supply will be natural gas, taken from the pipeline.

7.3.2 The Manufacturer shall ensure that the valve operator can operate at a power gas pressure range from a maximum working pressure of 9,930 kPa or greater, as specified on the data sheet, to a minimum of 2,410 kPa, unless otherwise specified in the purchase order or data sheet.

7.4 Valve Low Temperature Service

7.4.1 Buried valves will have a low service temperature of -5°C. Valves installed for above ground service will have a low service temperature of -45°C. The Company may specify lower temperatures than those specified above for buried and above ground service as required; in such cases, the specified minimum service temperature will be included in the purchase order or Company data sheet.

7.5 Speed Controls and Limiting Device

7.5.1 The Manufacturer shall ensure that independently adjustable speed controls are provided to regulate the operating speed of the valve over the stroking time.

7.5.2 The Manufacturer shall ensure that the maximum actuation time is as follows:

- For ball valves and plug valves: One second per inch of nominal valve size for valves NPS 16 and larger; 15 seconds for valves smaller than NPS 16.
- For gate valves: Five seconds per inch of nominal size.

7.6 Valve Torque and Thrust

7.6.1 The Manufacturer of the valve operator shall determine the minimum output torque or thrust of the valve operator, and applicable safety factors, over the range of operating pressures and temperatures specified in consultation with the valve manufacturer.

7.6.2 The Manufacturer shall ensure that the maximum operator torque (ball and plug valves) or thrust (gate and rising stem valves) required to operate the valve does not exceed the maximum safe allowable valve torque or thrust.

7.6.3 The Manufacturer shall ensure that the valve operator is capable of fully stroking the valve to an open or closed position over the range of operating pressures: from a maximum of 9,930 kPa to a minimum of 2,410 kPa, or as specified on the data sheet.

7.6.4 For calculating the operator torque or thrust requirements, the Manufacturer shall ensure that a maximum differential pressure across the valve is 9,930 kPa or as specified on the data sheet.

8 ELECTRICAL REQUIREMENTS

8.1 Classification of Equipment

8.1.1 The Manufacturer shall ensure that all electrical devices and enclosures are CSA approved for use in Class I, Division 1, Group D hazardous areas. All devices are to be NEMA recognized and IEC devices are not acceptable.

8.1.2 The Manufacturer shall ensure that electrical equipment bears the label of a recognized certification organization that indicates the equipment has been certified to CSA standards.

8.2 Solenoid Control Valves

8.2.1 The Manufacturer shall ensure that solenoid control valve coils are single-coil epoxy-potted with leads effectively sealed or clamped where the windings are connected.

8.2.2 The Manufacturer shall ensure that DC solenoids have a minimum operating range of -15% to +10% (dropout) of nominal voltage.

8.2.3 The Manufacturer shall ensure that solenoid voltage requirements are as specified on the data sheet.

8.2.4 The Manufacturer shall ensure that solenoid control valves can operate at an ambient temperature of -45°C.

8.2.5 The Manufacturer shall ensure that solenoids are 24 VDC.

8.3 Position Limit Switches

8.3.1 The Manufacturer shall ensure that valve operators are fitted with end-position limit switches to indicate both open and closed positions if required.

8.3.2 The Manufacturer shall ensure that limit switch assemblies permit end-of-valve-travel adjustment.

8.3.3 The Manufacturer shall ensure that limit switches be located inside a CSA approved enclosure.

8.3.4 The Manufacturer shall ensure that pressure and/or limit switch contact ratings are, at a minimum:

- 125 VDC 0.4 Amps (resistive)
- 24 VDC 1.00 Amps (resistive)
- 120 VAC 5 Amps (resistive)

8.4 Junction Box

The Manufacturer shall ensure that all electrical controls, limit switches, and solenoid valves are brought to terminal blocks in a common junction box, clearly marked for the Company's connections. This may be supplied as a separate junction box, or as part of the limit switch assembly.

8.4.1 The Manufacturer shall ensure that space is provided to allow for the installation of electrical suppression devices in the junction box.

8.4.2 The Manufacturer shall ensure that the junction box can accommodate a minimum size of 1 1/4 inch NPT conduit entry for customer connection, and is equipped with an internal grounding connection and terminal blocks capable of connecting 14 AWG conductors. All terminal blocks shall be screw type terminals.

8.4.3 The Manufacturer shall ensure that electrical components are corrosion-resistant and NEMA rated.

8.4.4 The Manufacturer shall ensure that all enclosures shall meet area classification requirements and shall be marked with appropriate certification. Mounting design and bracing shall be installed to allow ease of access to equipment and to minimize vibration. For outdoor applications, breathers and drains must be flush-mounted and installed to meet CEC requirements.

8.5 Pressure Switches

8.5.1 The Manufacturer shall ensure that pressure switches are installed on the valve operator. The requirements for these switches apply only to Valve Operator Packages SB-1930 to SB-1943.

9 EXAMINATION AND TESTING REQUIREMENTS

9.1 Radiographic Examination

9.1.1 Pressure containing butt weld seams in gas/hydraulic tanks and power gas storage tanks defined by ASME Section VIII and CSA B51 as pressure vessels shall be fully radiographed.

9.1.2 The Manufacturer shall ensure that radiographic techniques and acceptance standards are in accordance with *ASME Boiler and Pressure Vessel Code Section VIII, Division I,* paragraph UW-51.

9.1.3 Pressure containing butt weld seams in gas/hydraulic tanks and power gas storage tanks defined by *ASME Section VIII* and *CSA B51* as fittings shall be, as a minimum, subject to spot radiography in accordance with ASME *Boiler and Pressure Vessel Code* Section VIII, Division I.

9.2 Visual Examination

9.2.1 The Manufacturer shall ensure that all welds, as defined in section 3.2, are free of detrimental surface indications, including but not limited to, pinholes, cracks and undercuts.

9.2.2 The Manufacturer shall ensure that the welds are evaluated visually, or by using another suitable non-destructive examination method.

9.2.3 The Manufacturer shall ensure that any injurious indications detected are removed and/or repaired, as allowed by *ASME Section VIII, Division I*.

9.3 Pressure Testing

9.3.1 The Manufacturer shall ensure that the hydraulic system, including any CSA B51 or ASME Section VIII, Division I certified valve operator components that are part of the hydraulic system, are hydrostatically pressure tested at 1.5 times their design pressure for a minimum of 30 minutes.

9.3.2 The Manufacturer shall ensure that pressure charts are supplied to the Company identifying the date, test number, purchase order number, the test pressure, test duration, and any additional test details, as stated on the purchase order.

9.3.3 The Manufacturer shall ensure that the completely assembled valve operator package is dry-compressed air-tested at 1.1 times the design pressure and checked for leakage.

9.4 Function Testing

9.4.1 The Manufacturer shall ensure that the complete valve operator package is function-tested. The tests shall conform, as closely as possible, to actual field-operating conditions.

10 TECHNICAL DOCUMENTATION

10.1 Reports and Certificates

10.1.1 Prior to shipping the valve operator, the Manufacturer shall supply to the Company, or its representative, one (1) copy of the reports and test certificates.

10.1.2 The reports and test certificates shall contain the following information with a cover transmittal listing the documents in the order attached:

1. Material test results for pressure containing components
2. Hydrostatic test charts
3. Certification of the weld procedures used
4. Nondestructive examination records
5. ASME data sheet U1A, if applicable
6. Confirmation that the valve operator was manufactured in accordance with this specification and revision date
7. Company Purchase Order Number (P.O. No.) and Construction Project Number (C.O. No.), if applicable
8. One copy of the Manufacturer’s approved drawing(s) that were shop referenced in the purchase order or confirmation of order
9. One photocopy of the serial name plates for the specific operator(s) related to the purchase order
10. Enclosure certification for area classification application (where applicable)

10.2 Instruction Manuals

10.2.1 Two (2) copies of the instruction manuals shall be shipped with the valve operator to the site.

10.2.2 One (1) copy of the instruction manuals shall be shipped to the Company’s head office Vendor Document Control.

10.2.3 Each instruction manual shall include the following:

- equipment description including design data, ratings, and set points
- installation instructions and operation procedures
- maintenance and troubleshooting procedures
- reduced size assembly, control and schematic drawings and bills of materials

11 PREPARATION FOR SHIPMENT

11.1.1 The Manufacturer shall ship the valve operators in the fully open position, individually boxed or crated as necessary for protection against mechanical and environmental damage during shipment. Items that must be shipped loose shall be placed in a separate container that is tagged for identification.

11.1.2 The Manufacturer shall lightly grease exposed machined surfaces and ensure they are protected from damage.

12 VALVE OPERATOR PACKAGES

12.1 General

12.1.1 Functional Applications

Functional applications, per sections 12.2, 12.3 and 12.4, describe the facility reference and titles of the valve. A Valve Operator Package (VOP) number references each application and provides the functional design requirements, the Manufacturer's standard schematic, and wiring drawing numbers for procurement of a gas hydraulic valve operator.

12.1.2 Standard Valve Operator Packages

A Standard Valve Operator Package number identifies the instrumentation and control requirements for each valve functional application. The valve operator packages are identified as VOP-1 to VOP-12, SB-1930 to SB-1943, and VOP-100, VOP-101.

The Company shall note and enter this number in the project data sheet and in the purchase requisition/order when specifying the valve operator for procurement.

The Manufacturer does not require a copy of the project data sheet because the valve operator Vendor drawings are approved for each Standard Valve Operator Package number. Data sheets for non-standard valve operator packages, other than the ones listed previously, will be required on a project-specific basis.

12.1.3 Valve Operator Data Sheet Templates

A standard data sheet template for each valve operator package is used to identify the specific site requirements. The data sheet templates are identified as VOP-1 to VOP-12, SB-1930 to SB-1943, and VOP-100 and VOP-101.

VOP-1 to VOP-12 can be used on all TransCanada systems. SB-1930 to SB-1943 can only be used on TransCanada Mainline systems east of Alberta where existing facilities already have the controls systems in place pertaining to the SB packages.

The Company shall update the data sheets for site-specific design with reference and service information, such as project name, and tagging and valve information. The technical requirements are standardized with Vendor drawing approval.

12.2 Valve Operator Package Descriptions (VOP-1 to VOP-12)

12.2.1 The technical requirements for valve operator packages VOP-1 to VOP-12 are summarized in the following table. See Appendix A for approved schematic and wiring diagram numbers that represent each vendor-approved valve operator package.

Table 12-1: Valve Operator Packages VOP-1 to VOP-12

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS (E.g.)	FUNCTIONAL REQUIREMENTS
VOP-1	Pipeline Scraper Trap, Isolation Valve	• Manual operation • No I&C requirements • Power gas high pressure selector valve
VOP-2	Pipeline Mainline, Side, Crossover, Isolation Valve	• Manual operation • Low pressure closedown device (set point 3,450 kPa(g) falling) • Auto/maintenance selector valve • Low pressure select manifold • Power gas high pressure selector valve
VOP-3	Pipeline Mainline, Side, Crossover, Isolation Valve	• Manual operation • High pressure closedown device (set point 7,500 kPa(g) rising) • Auto/maintenance selector valve • High pressure select manifold • Power gas high pressure selector valve
VOP-4	Pipeline Mainline, Side, Crossover, Isolation Valve	• Manual operation • Low pressure closedown device (set point 3,450 kPa(g) falling) • Auto/maintenance selector valve • Limit switch assembly • Low pressure select manifold • Power gas high pressure selector valve

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS (E.g.)	FUNCTIONAL REQUIREMENTS
VOP-5	Pipeline Mainline, Side, Crossover, Isolation Valve	• Manual operation • High pressure closedown device (set point 7,500 kPa(g) rising) • Auto/maintenance selector valve • Limit switch assembly • High pressure select manifold • Power gas high pressure selector valve
VOP-6	Compressor Station Mainline Block Valve (Pre-1996 Design)	• One way remote control • Low pressure closedown device (set point 3,450 kPa(g) falling) • Differential pressure inhibit device (set point 350 kPa(g) falling) • Bi-directional differential pressure selector • Auto/maintenance selector valve • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (one solenoid): ▪ De-energize to open ▪ Energize to enable manual close
VOP-7	Compressor Station Mainline Block Valve (Post 1996 Design)	• Two way remote control • Low pressure closedown device (set point 3,450 kPa(g) falling) • Differential pressure inhibit device (set point 350 kPa(g) falling) • Bi-directional differential pressure selector • Auto/maintenance selector valve • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (one solenoid): ▪ De-energize to open ▪ Energize to close

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS (E.g.)	FUNCTIONAL REQUIREMENTS
VOP-8	Compressor Station Suction/Discharge Side Valve, Isolation Valve	• One way remote control • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (one solenoid): ▪ De-energize to close ▪ Energize to enable manual open
VOP-9	Compressor Station Blowdown Valve	• One way remote control • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (one solenoid): ▪ De-energize to open ▪ Energize to enable manual close
VOP-10	Meter Station/Pipeline Run Switching Valve, Yard Valve	• Two way remote control • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (two solenoids): ▪ Energize to open ▪ Energize to close
VOP-11	Meter Station Sour Gas Block Valve	• One way remote control • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (one solenoid): ▪ Energize to close ▪ De-energize to enable manual open
VOP-12	Meter Station Sour Gas Block Valve	• Two way remote control • Limit switch assembly • Differential pressure inhibit device (set point 350 kPa(g) falling) • Bi-directional differential pressure selector • Power gas high pressure selector valve • Solenoid control (two solenoids): ▪ Energize to open ▪ Energize to close

12.3 Valve Operator Package Descriptions (SB-1930 to SB-1943)

The technical requirements for valve operator packages SB-1930 to SB-1943 are provided in the following section. The approved Vendor schematic and wiring drawing numbers represent each valve operator packages as shown in Appendix B.

12.3.1 Pressure Switches, General Guidelines

The Manufacturer shall ensure that the valve operator, unless otherwise specified on the data sheets, includes a DPDT (Double Pole Double Throw) pressure switch connected to the power gas supply. The pressure switch shall be adjustable over a pressure range 2,000 kPa to 4,000 kPa and set to open at 2,800 kPa decreasing, unless otherwise specified in the data sheets.

1. Station Mainline Valves:
    - MLV PSL Pilot gas low pressure Single Pole Double Throw (SPDT) set at 550 kPa decreasing
    - ML PSL Mainline low discharge pressure DPDT set at 3,450 kPa decreasing
2. Station Side Valves Unit Suction and Plant Isolation Valves:
    - PDSL Pressure differential low DPDT set at 690 kPa decreasing
    - PR Line pressurized SPDT set at 690 kPa increasing
3. Suction and Discharge Blow-offs:
    - PSH Pressure switch high DPDT set as specified on the data sheets and to meet site requirements.

12.3.2 Main Line (Station By-Pass) Valve

The Manufacturer shall ensure that the Main Line (Station By-pass) valve operator is controlled by differential pressure across the main line valve, a *Lock-Closed* solenoid valve, a *Close* solenoid valve and a downstream pressure controlled pilot valve.

1. The Main Line Valve shall open if:
    - The line pressure on the suction side of the valve is greater than 35 kPa above the line pressure on the discharge side.
    - The *Lock-Closed* solenoid is de-energized.

    The set point of the differential control device shall be adjustable from approximately 0 kPa to 100 kPa.
2. A Main Line valve that is closed will remain closed if:
    - The *Lock-Closed* solenoid is energized, or
    - The line pressure on the discharge side of the valve is greater than on the suction side by 100 kPa.

3. The Main Line valve will close only if both the *Close* and *Lock-Closed* solenoids are energized. The *Close* solenoid will be de-energized when the valve has reached the closed position.
4. A low downstream pressure of 3,450 kPa falling (or as specified in the data sheets) shall cause the valve to close, if not already closed, and to stay closed until manually reset. As a minimum the set point of the sensing device shall be adjustable from 2,000 kPa to 5,520 kPa.
5. A pressure switch (MLV PSL) shall be activated at 550 kPa decreasing on low pilot gas pressure, indicating that the valve closed pneumatically on low downstream pressure.

12.3.3 Side and Isolation Valve

The Manufacturer shall ensure that a *Fail-safe* solenoid and an *Open* solenoid control side and isolation valve operators.

- The *Fail-safe* solenoid shall, when it is de-energized, cause the valve to close.
- The *Open* solenoid, when energized, shall cause the valve to open, but only if the *Fail-safe* solenoid is also energized. The *Open* solenoid shall be de-energized when the valve has reached its fully open position.

12.3.4 Suction and Discharge Blow-off Valve

The Manufacturer shall ensure that Suction and Discharge Blow-off valve operators are controlled by a *Close* solenoid, a *Fail-safe* solenoid, and a pressure relief switch.

- The valve shall close when the *Close* solenoid and the *Fail-safe* solenoid are energized. The *Close* solenoid shall be de-energized when the valve has reached its fully closed position.
- The valve shall open when the *Fail-safe* solenoid is de-energized.
- The valve shall open by de-energizing the *Fail-safe* solenoid when the line pressure is greater than the set point of the pressure relief switch. The valve will close when the switch has passed through its deadband, re-energizing both solenoids.

12.3.5 Crossover and Series Valve

The Manufacturer shall ensure that Crossover and Series valve operators are controlled by a *Fail-safe* solenoid and an *Open* solenoid.

- The *Fail-safe* solenoid shall, when it is de-energized, cause the valve to close.
- The *Open* solenoid, when energized, shall cause the valve to open, but only if the *Fail-safe* solenoid is also energized. The *Open* solenoid shall be de-energized when the valve has reached its fully open position.

12.3.6 Unit Suction Valve

The Manufacturer shall ensure that Unit Suction valve operators are controlled by a *Fail-safe* solenoid and an *Open* solenoid.

- The *Fail-safe* solenoid shall, when it is de-energized, cause the valve to close.
- The *Open* solenoid, when energized, shall cause the valve to open, but only if the *Fail-safe* solenoid is also energized. The *Open* solenoid shall be de-energized when the valve has reached its fully open position.

12.3.7 Unit Discharge Valve

The Manufacturer shall ensure that Unit Discharge valve operators are controlled by a *Fail-safe* solenoid and an *Open* solenoid.

- The *Fail-safe* solenoid shall, when it is de-energized, cause the valve to close.
- The *Open* solenoid, when energized, shall cause the valve to open, but only if the *Fail-safe* solenoid is also energized. The *Open* solenoid shall be de-energized when the valve has reached its fully open position.

12.3.8 Reciprocating Compressor Valve

The Manufacturer shall ensure that Reciprocating Compressor Unit valve operators are controlled by a *Close* solenoid and *Open* solenoid.

- The *Close* solenoid shall, when it is energized, cause the valve to close. The solenoid shall be de-energized when the valve has reached its fully closed position.
- The *Open* solenoid shall, when it is energized, cause the valve to open. The solenoid shall be de-energized when the valve has reached its fully open position.

12.3.9 Compressor Station Tie-Over Valve

The Manufacturer shall ensure that Compressor Station Tie-Over valve operators are controlled by a *Fail-safe* solenoid and an *Open* solenoid.

- The *Fail-safe* solenoid shall, when it is de-energized, cause the valve to close.
- The *Open* solenoid, when energized, shall cause the valve to open, but only if the *Fail-safe* solenoid is also energized. The *Open* solenoid shall be de-energized when the valve has reached its fully open position.

12.3.10 Main Line (Pipeline) Valve and Loop Terminus Tie-Over Valve

The Manufacturer shall ensure that Main Line (Pipeline) and Loop Terminus Tie-Over valve operators incorporate the following features:

- Low Pressure Shut-off: A low downstream pressure of 3,450 kPa falling (or as specified in the data sheets) shall cause the valve to close if not already closed, and to stay closed until manually reset.
- Maintenance Mode: The low pressure shut-off function shall be defeated in this mode. This isolation of the low pressure shut-off feature shall allow maintenance and calibration checks of the low pressure shut-off devices without causing the Operator to close the valve.

- A power gas storage tank shall be provided as part of the valve Operator assembly. The power gas storage tank shall be connected to the pipeline by a check valve that will ensure the storage tank pressure equals the maximum pipeline pressure.
- Limit switches and solenoid valves for remote valve operation and monitoring will not be required unless stated on the data sheets. If required, remote operation and monitoring shall be controlled by a *Close* solenoid and an *Open* solenoid.
- The *Close* solenoid shall, when it is energized, cause the valve to close. The solenoid shall be de-energized when the valve has reached its fully closed position.
- The *Open* solenoid shall, when it is energized, cause the valve to open. The solenoid shall be de-energized when the valve has reached its fully open position.

12.3.11 Launcher/Receiver Valve

The Manufacturer shall ensure that launcher and receiver valve operators are supplied with manual controls.

12.3.12 Valve Operator Package Descriptions

The technical requirements for valve operator packages B-1930 to SB-1943 are summarized in the following table. These valve operator packages reflect the Company's Alberta facilities. See Appendix A for approved schematic and wiring diagram numbers that represent each vendor-approved valve operator package.

Table 12-2: Valve Operator Package Table SB-1930 to SB-1943

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS	FUNCTIONAL REQUIREMENTS
SB-1930	MAINLINE Station By-pass Valve	• Two solenoids – de-energize to open, energize to close • Limit switch • PGL, MLV PSL, and ML PSL pressure switches • Regulator and relief • J1 differential pilot or equivalent, end of stroke • Low pressure closedown device with manual reset • SJ31-B junction box or equivalent

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS	FUNCTIONAL REQUIREMENTS
SB-1931	PLANT Suction & Discharge Side Valve or Isolation Valve	• Two solenoids – energize to open, de-energize to close • Limit switch • SJ31-B junction box or equivalent • PGL pressure switch • PDSL differential pressure switch • PR line pressurized
SB-1932	PLANT Suction & Discharge Blow-Off Valve or Isolation Blow-Off Valve	• Two solenoids – de-energize to open, energize to close • Limit switch • SJ31-B junction box or equivalent • PGL pressure switch • PSH pressure switch
SB-1933	PLANT Suction & Discharge Crossover Valve, (Series Valve)	• Two solenoids – energize to open, de-energize to close • Limit switch • SJ31-B junction box or equivalent • PGL pressure switch • PDSL differential pressure switch • DPS-2F differential pressure selector or equivalent
SB-1934	UNIT Suction Valve	• Two solenoids – energize to open, de-energize to close • Limit switch • L.P. pressure switch • PDSL differential pressure switch • SJ31-B junction box or equivalent
SB-1935	UNIT Discharge Valve	• Two solenoids – energize to open, de-energize to close • Limit switch • PGL power gas pressure switch • SJ31-B junction box or equivalent
SB-1936	TAP VALVE, Recip. Compressor Unit Valve	• Two solenoids – energize both ways • Limit switch • PGL pressure switch • SJ31-B junction box or equivalent

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS	FUNCTIONAL REQUIREMENTS
SB-1937	LOOP TERMINUS Tie-Over Valve (Linear)	• Two solenoids – energize both ways • Limit switches • PGL pressure switch • Regulator and relief • End of stroke • PSL pressure switch • SJ31 junction box or equivalent • Low pressure closedown device shuttle valve • Storage tank with HP and check valve (extra) • Auto/maintenance selector valve
SB-1938	MAINLINE Pipeline Valve	• Pressurematic • R324 reversing relay or equivalent • End of stroke • Regular and relief • Storage tank with HP relief and check valve (extra) • Auto/Maintenance Selector Valve
SB-1939	LAUNCHER & RECEIVER Valve	• Two-way manual
SB-1940	STATION Upstream & Downstream Tie-Over Valve (Linear)	• Two solenoids – energize to open, de-energize to close • Limit switches • SJ31-B junction box or equivalent • PGL pressure switch
SB-1941	MAINLINE Pipeline Valve - Remote Control	• Two solenoids – energize both ways • Limit switch • PGL pressure switch • Regulator and relief • End of stroke • PSL pressure switch • SJ31 junction box or equivalent • Low pressure closedown device shuttle valve • Storage tank with HP relief and check valve (extra) • Auto/maintenance selector valve
SB-1942	LAUNCHER & RECEIVER By-pass Valve	• Two way manual • 3/4” locking block

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS	FUNCTIONAL REQUIREMENTS
SB-1943	PLANT Suction & Discharge Side Valve or Isolation Valve (Linear)	• Two solenoids – energize to open, de-energize to close • Limit switches • SJ31-B junction box or equivalent • PGL pressure switch • PDSL differential pressure switch • PR line pressurized pressure switch

12.4 Valve Operator Package Descriptions (VOP-100 to VOP-101)

12.4.1 Valve Operator Package Descriptions

The technical requirements for valve operator packages VOP-100 and VOP-101 are summarized in the following table. Gas/Pneumatic operators are used for VOP 100 and 101. These valve operator packages are typically used for skid-mounted meter stations. See Appendix A for approved schematic and wiring diagram numbers that represent each vendor-approved valve operator package.

Table 12-3: Valve Operator Packages VOP-100 and VOP-101

VALVE OPERATOR PACKAGE #	FUNCTIONAL APPLICATIONS	FUNCTIONAL REQUIREMENTS
VOP-100	Meter Station Sour Gas Block Valve	• One way remote control • Limit switch assembly • Solenoid control (One Solenoid): ▪ Energize to close ▪ De-energize to enable manual open • Disconnect and wrench override
VOP-101	Meter Station Auto/Sour Gas Block Valve	• Two way remote control • Limit switch assembly • Differential pressure inhibit device (set point 350 kPa(g) falling), • Bi-directional differential pressure selector • Solenoid control (two solenoids): ▪ Energize to open ▪ Energize to close • Desiccant filter package • Pressure regulating system • Disconnect and wrench override

13 VARIANCES

Any deviation shall follow the TransCanada Management of Change (MOC) Variance Procedure. External Manufacturers shall contact the TransCanada Mechanical Design Engineer for variance approval.

14 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are detailed below in Table 14-1. Use the latest document revision, unless otherwise approved by TransCanada.

Table 14-1: External and Internal References

Document No.	Title
NEB OPR SOR/99-294	National Energy Board Onshore Pipeline Regulations (NEB OPR)
Industry Codes and Standards	
American Society of Mechanical Engineers (ASME)	Boiler and Pressure Vessel Code, Section VIII, Div. 1 Pressure Vessels
	ASME Boiler and Pressure Vessel Code, Section IX
	B31.3 Process Piping
ASTM Standard E384	Standard Test Method for Knoop and Vickers Hardness of Materials
ASTM A269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A182	Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
Canadian Standards Association (CSA)	B51 Code for the Construction and Inspection of Boilers and Pressure Vessels
	C22.1 Canadian Electrical Code Part 1, Safety Standard for Installations
	Z662 Oil and Gas Pipeline Systems
National Electrical Manufacturers' Association (NEMA)	ICS 1 – General Standards for Industrial Control and Systems
	ICS 1.1 – Safety Guidelines for the Application, Installation and Maintenance of Solid State Control
	ICS 4 – Terminal Blocks
	ICS 6 – Industrial Control and Systems Enclosures

Document No.	Title
Internal References – Documents Referenced by this Standard / Specification	
STDS-01-VA-03-001	Power Gas Installations VOP-1 to VOP-12
EDMS No. 1002558850	Valve Operator Datasheet Template VOP 100, 101
EDMS No. 1002558685	Valve Operator Datasheet Template SB1930-SB1943
EDMS No. 1002558787	Valve Operator Datasheet Template VOP 1-12

15 DOCUMENT HISTORY

Rev.		
02	**Description**	
	New Document.	2017-Feb-02
	Rationale Statement	
	This document merges the requirements of, and supersedes, the following Specifications: • TES-VOPR-GH Gas Hydraulic Valve Operator Specification (CDN) • TEP-VOPR-GH Gas Hydraulic Valve Operator Packages and Functional Applications • TCPL MS 12-001, Gas Powered Hydraulic Valve Operators • OVA Specification VO-1, Valve Operators – Gas / Hydraulic • ANG Specification ES 1202P, General Specification for Gas Powered Hydraulic Valve Operators It also complies with the new Company Specifications template.	Jason Lu, P.Eng.
	Impact Assessment Summary	
	N/A	Jason Lu, P.Eng.

16 APPROVALS

APPROVALS		
Originator: David Scalzo, EIT Design Services	Signature	Jan. 25, 2017 Date
Reviewer: Dmitry Ryapolov P. Eng. CGO Technical Support	Signature #84006	Feb 02, 2017 Date
Reviewer: Pam Balderston, P. Eng. Pipeline Engineering	Signature	Feb 1, 2017 Date
Reviewer: Jim W. White, P. Eng. Coastal GasLink Project	Signature	Feb 1, 2017 Date
Reviewer: Steve Foo, P. Eng. Measurement Engineering	Signature	Jan. 27, 2017 Date
Reviewer: Gerard Lalonde, P. Eng. Design Services	Signature	Jan 25/2017 Date
Responsible Engineer: Jason Lu, P. Eng. Design Services	Signature Feb. 02. 2017 Date	PROFESSIONAL ENGINEER JASON S. LU ALBERTA APEGA Permit to Practice P7100
Management Endorsement: Muhammad Riaz, Manager Design Services	Signature	Feb. 02, 2017 Date

APPENDIX A VALVE OPERATOR PACKAGE VENDOR DRAWINGS

Table 16-1: Valve Operator Package Vendor Drawings

VALVE OPERATOR PACKAGE #	EMERSON STANDARD DWG NO.		VALVITALIA STANDARD DWG NO.		BIFFI STANDARD DWG NO. (Note 1)	
	Schematic	Wiring Diagram	Schematic	Wiring Diagram	Schematic	Wiring Diagram
VOP-1	E-65000050	N/A	SF-GO-355	N/A	GIG-VOP-1, GPO-VOP-1	
VOP-2	E-65000346	N/A	SF-GO-353	N/A	GIG-VOP-2, GPO-VOP-2	
VOP-3	E-65000347	N/A	SF-GO-356	N/A	GIG-VOP-3, GPO-VOP-3	
VOP-4	E-65000348	E-65500050	SF-GO-357	SE-14-004	GIG-VOP-4, GPO-VOP-4	SEAAF049
VOP-5	E-65000349	E-65500050	SF-GO-358	SE-14-004	GIG-VOP-5, GPO-VOP-5	SEAAF049
VOP-6	E-65000350	E-65500051	SF-GO-359	SE-14-030	GIG-VOP-6, GPO-VOP-6	SEAAF049, SEADA172
VOP-7	E-65000351	E-65500052	SF-GO-378	SE-14-031	GIG-VOP-7, GPO-VOP-7	SEAAF049, VOP-7
VOP-8	E-65000340	E-65500052	SF-GO-379	SE-14-031	GIG-VOP-8, GPO-VOP-8	SEAAF049, VOP-8
VOP-9	E-65000353	E-65500051	SF-GO-380	SE-14-030	GIG-VOP-9, GPO-VOP-9	SEAAF049, VOP-6/VOP-9
VOP-10	E-65000354	E-65500053	SF-GO-381	SE-24-042	GIG-VOP-10, GPO-VOP-10	SEAAF049, VOP-10/VOP-12
VOP-11	E-65000355	E-65500053	SF-GO-360	SE-14-032	GIG-VOP-11, GPO-VOP-11	SEAAF049, VOP-11
VOP-12	E-65000356	E-65500053	SF-GO-354	SE-24-042	GIG-VOP-12, GPO-VOP-12	SEAAF049, VOP-10/VOP-12
SB-1930	E-65000070	E-65500070	N/A	N/A	GIG-SB-1930, GPO-SB-1930	SB-1930
SB-1931	E-65000071	E-65500071	N/A	N/A	GIG-SB-1931, GPO-SB-1931	SB-1931

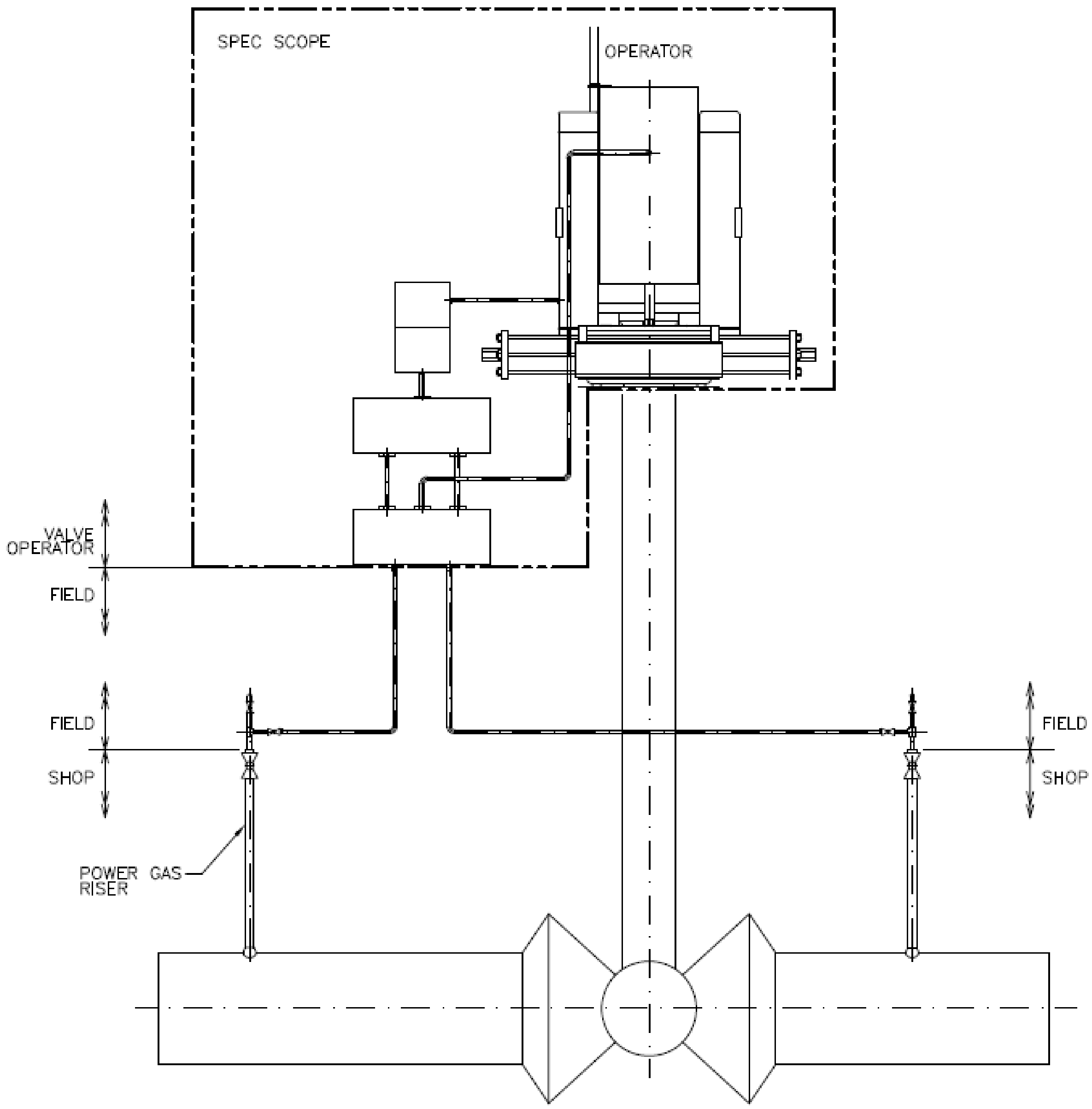
VALVE OPERATOR PACKAGE #	EMERSON STANDARD DWG NO.		VALVITALIA STANDARD DWG NO.		BIFFI STANDARD DWG NO. (Note 1)	
	Schematic	Wiring Diagram	Schematic	Wiring Diagram	Schematic	Wiring Diagram
SB-1932	E-65000072	E-65500072	N/A	N/A	GIG-SB-1932, GPO-SB-1932	SB-1932
SB-1933	E-65000073	E-65500073	N/A	N/A	GIG-SB-1933, GPO-SB-1933	SB-1933
SB-1934	E-65000074	E-65500074	N/A	N/A	GIG-SB-1934, GPO-SB-1934	SB-1934
SB-1935	E-65000075	E-65500075	N/A	N/A	GIG-SB-1935, GPO-SB-1935	SB-1935
SB-1936	E-65000076	E-65500076	N/A	N/A	GIG-SB-1936, GPO-SB-1936	SB-1936
SB-1937	E-65000077	E-65500077	N/A	N/A	GIG-SB-1937, GPO-SB-1937	SB-1937
SB-1938	E-65000078	E-65500078	N/A	N/A	GIG-SB-1938, GPO-SB-1938	N/A
SB-1939	E-65000079	E-65500079	N/A	N/A	GIG-SB-1939, GPO-SB-1939	N/A
SB-1940	E-65000080	E-65500080	N/A	N/A	GIG-SB-1940, GPO-SB-1940	SB-1940
SB-1941	E-65000081	E-65500081	N/A	N/A	GIG-SB-1941, GPO-SB-1941	SB-1941
SB-1942	E-65000082	E-65500082	N/A	N/A	GIG-SB-1942, GPO-SB-1942	N/A
SB-1943	E-65000083	E-65500083	N/A	N/A	GIG-SB-1943, GPO-SB-1943	SB-1943
VOP-100	SB-0326-71	S-0181-X01	N/A	N/A	N/A	N/A
VOP-101	SB-1114-7M	S-0225-X00	N/A	N/A	N/A	N/A

Note:

1. Link to BIFFI standard drawing and wiring diagram in EDMS will be added.

APPENDIX B SPECIFICATION SCOPE DRAWINGS

Figure B-16-1: Specification Scope



PURPOSE

This Specification outlines the requirements for the materials, qualification, manufacture, testing and inspection of double submerged arc welded steel line pipe.

SCOPE/APPLICABILITY

This Specification applies to double submerged arc welded pipe purchased for use in the Company's non-sour natural gas and liquid hydrocarbon pipeline systems in Canada, the United States (U.S.) and Mexico.

This Specification applies to pipe having a specified outside diameter (OD) of 406.4 mm OD (NPS 16) or larger, and pipe grade L690M (X100M) or lower.

This Specification does not apply to pipe for strain-based design, offshore and sour service.

This Specification is to be used in conjunction with the American Petroleum Institute (API) 5L *Specification for Line Pipe*, latest revision. This Specification covers requirements in addition to those of API 5L and any amendment, supplement or errata issued by API. All pipe shall meet, as a minimum, the requirements of API 5L.

The headings and numbering in this Specification correspond to those in API 5L. Where no incremental requirements are given in this Specification, API 5L shall apply as written. If conflict exists between this Specification and the requirements in API 5L, the more stringent of the requirements shall apply.

The Responsible Engineer shall be contacted for clarification if needed.

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GLOSSARY

ASME

American Society of Mechanical Engineers

ASTM

American Society for Testing and Material

CFR

Code of Federal Regulations

Company or Purchaser

TransCanada PipeLines Limited, its corporate affiliate or its agent.

CSA

Canadian Standards Association

DOT

United States Department of Transportation

Double-Jointer

Two pieces of pipe welded together to make a length 50 ft. (15.0 m) or longer.

ISO

International Organization for Standardization

Manufacturer or Vendor

Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.

MSS

Manufacturer Standardization Society

NEB

National Energy Board

NOM

Norma Oficial Mexicana

Purchase order

The purchasing document used to purchase the specified item(s).

Recrushed flux

Flux that fused during the original welding operation and has been ground and cleaned for re-use on subsequent welding.

Regulatory Authority

The national and/or local regulator having jurisdiction over the facility.

Rolling practice

The rolling parameters, which are within the essential parameters stated, are applied to a steel of specific alloy design to produce a steel having a desired set of physical properties.

Single-Jointer

Two pieces of pipe welded together to make a length shorter than 50 ft. (15.0 m).

Steelmaking practice

The specified chemical composition (including specified tolerances), refining and casting process used in making a heat of solid steel.

T-Joints

The junctions between the skelp end welds and helical seam welds.

Technical Agreement

The document signed by the Company and the Manufacturer that states an agreement on a technical matter.

Triple-Jointer

Three pieces of pipe welded together to make a length 50 ft. (15.0 m) or longer.

Virgin Flux

Flux that has not been used before or flux that has been used but did not fuse during the welding operation.

Welding Procedure

The Welding Procedure Specification, Procedure Qualification Record and all associated non-destructive and destructive test data.

WIC

Welding Institute of Canada

1 SCOPE

1.1 Purpose and Coverage

1.1.1 The requirements of the Annex documents referenced in this Specification, and the applicable Annex documents referenced in API 5L including Addendum documents thereto, shall be met as applicable. When specified, the pipe shall be dual-certified to meet CSA Z245.1, latest revision.

Pipe shall be supplied to meet the additional requirements outlined on the purchase order documentation or requests for proposal, whichever is applicable.

6 PIPE GRADE, STEEL GRADE AND DELIVERY CONDITION

6.2 Delivery Condition

6.2.3 All pipe shall, as a minimum, meet the product specification level PSL 2 requirements in regard to API 5L and Category II in regard to CSA Z245.1, if specified.

6.3 Right of Rejection

6.3.1 Where less than 50% of the pipe length formed from any heat, rolling practice, coil or lot complies with all other requirements of this Specification, the Company reserves the right to reject all pipe from the affected heat, rolling practice, coil or lot. The Manufacturer is responsible for obtaining the Company's written authorization prior to the acceptance of any pipe from such heats, rolling practice, coils or lots.

Note:

Right of rejection shall apply to issues associated with the manufacturing process.

6.4 Welder Qualifications

6.4.1 Pipe supplied for welder qualifications shall be of the highest carbon equivalent of the order.

8 MANUFACTURING

8.1 Process of Manufacture

8.1.1 Pipe furnished to this Specification shall be double submerged arc welded as defined in Clause 4.52, Clause 4.53, or Clause 4.54 of API 5L, as applicable.

8.3 Starting Material

8.3.2.1 The steel used for the manufacture of pipe shall be micro-alloyed, fine grain, fully killed, continuously cast steel with inclusion shape control. The steelmaking practice shall be identified with a steelmaking practice number.

8.3.2.2 The rolling practice shall be identified with a rolling practice number.

8.3.2.3 All skelp or all pipe shall be inspected for laminar-type imperfections by an ultrasonic procedure submitted to and accepted by the Company in writing prior to the commencement of production.

8.3.2.3.1 Any lamination in the body of the pipe or skelp shall be considered a defect if its non-destructively determined dimensions exceed both of the following:

a) ≥ 20 mm (0.79 in.) in the circumferential direction, and

b) an area of 7000 mm^2 (10.85 in^2.)

8.3.2.4 For all casting methods, the Manufacturer shall have a written method of monitoring the severity of centerline segregation present in either the slab or skelp to minimize the extent of segregation. This method shall be made available to the Company on request. The centerline segregation acceptance level shall be presented as part of the bid documentation.

8.3.10 Susceptibility of Pipe to Stress Relieving

Unless otherwise specified, tests outlined in Annex R of this Specification shall be conducted on pipe with a specified wall thickness greater than 31.8 mm (1.25 in.) to determine its susceptibility to stress relieving.

8.6 Weld Seams in SAW Pipe

8.6.1 Welding Procedure Qualification

8.6.1.1 a) Welding procedures for the longitudinal, helical, skelp end and circumferential welds, whichever are applicable, shall be qualified in accordance with the requirements of the latest edition of ASME *Boiler and Pressure Vessel Code* (BPVC), Section IX for each welding process, and for each flux trade name/designation and electrode designation combination employed.

b) When 100% virgin flux is used in production, the qualification tests shall be completed with virgin flux. When any amount of recrushed flux is used, the qualification tests shall include the recrushed flux. The percentage of recrushed flux used during production shall not exceed that used for the qualification tests.

8.6.1.2 A separate Procedure Qualification Record (PQR) shall be prepared for each grade of material. A change in grade shall be considered a change in an essential variable. The Welding Procedure Specification (WPS) and the PQR shall show "API 5L, Grade XXXXX"; where "XXXXX" is the grade defined in API 5L.

8.6.1.3 If the welding procedures to be used have not previously been accepted by the Company in writing, they shall be submitted for review and written acceptance by the Company. Pipe will not be considered for acceptance by the Company until the welding procedures have been accepted. Prior to the start of production, the Manufacturer shall provide the Company with the procedure numbers to be used for previously accepted procedures.

8.6.1.4 Procedure qualification testing shall include Charpy impact tests of the weld and heat-affected zone. Energy absorption and shear area requirements shall be in accordance with the requirements of Clause 9.8.3 and Table 9-3 of this Specification. Test temperature shall be as specified in the purchase order. Tests conducted at lower temperatures shall be considered acceptable if the specified absorbed energy values are met at the lower test temperature.

8.6.1.5 Procedure qualification tests shall include at least two macrohardness traverses across the weld, heat-affected zones and parent metal. One traverse shall be between 1 and 2 mm (0.04 and 0.08 in.) from the outside surface of the test specimen and one traverse shall be between 1 and 2 mm (0.04 and 0.08 in.) from the inside surface of the test specimen. Each traverse shall consist of the following: at least two readings taken within the weld, at least two readings on each side of the weld in the heat-affected zone, and at least two readings on each side of the weld in the parent metal. Along each traverse, the hardness indentations shall be made on the microstructures expected to have the highest hardness within each zone. All results, including reading locations and distances from the specimen surface, shall be reported.

8.6.1.6 Macrohardness tests shall be conducted in accordance with the requirements of ASTM Standard E92.

8.6.1.7 The maximum macrohardness shall be 280 HV using a load of 10 kg.

8.6.2 Repair Welding

8.6.2.1 Limitations on Repair Welding

Defects in the longitudinal, helical or circumferential seams, or in skelp end welds of double submerged arc welded pipe, shall be subjected to weld repair in accordance with requirements of this Specification, and Annex C of API 5L. In addition to requirements outlined in C.4 of Annex C of API 5L, the following requirements shall apply:

a) All repairs by welding using other than the submerged arc process shall be preheated to a temperature of at least 120°C (250°F). Care should be taken to prevent overheating and no part of the area shall be heated above 200°C (392°F) unless the effects of the time-temperature relationship on the mechanical properties of the pipe are taken into consideration.

b) The depth of the repair cavity, excluding any contribution from the weld bead height, shall be in excess of 1.5 mm (1/16 in.) but shall not exceed 2/3 of the specified wall thickness.

c) The minimum distance of a repair weld from the pipe end shall be 300 mm (12 in.).

d) The minimum distance between any two repaired weld locations shall be 300 mm (12 in.).

e) The length of weld repairs shall not exceed 30% of the specified outside diameter.

f) Back-to-back repairs shall not be permitted.

g) Additional repair to a previously repaired area shall not be permitted.

h) For welds other than circumferential jointer welds, the maximum number of weld repairs in any pipe shall not exceed an average of one weld repair per 3 m (10 ft.) of total weld length, and no weld repair may be repeated.

i) Repairs to defects detected by ultrasonic inspection shall be examined by ultrasonic techniques in addition to film radiographic techniques or non-film radiographic imaging techniques.

Cracks in either the original weld or repair welds are not acceptable, and the area of the pipe containing the crack shall be removed as a cylinder.

8.6.2.2 Repair Welding Procedure Qualification – Additional Tests

8.6.2.2.1 Repair welding procedure qualifications shall be carried out in accordance with the requirements of this Specification, and those outlined in Annex D of API 5L.

8.6.2.2.2 Procedure qualification testing shall also include Charpy impact tests of the weld and heat-affected zone. Energy absorption and shear area requirements shall be in accordance with the requirements of Clause 9.8.3 and Table 9-3 of this Specification. Test temperature shall be as specified in the purchase order. Tests conducted at lower temperatures shall be considered acceptable if the specified absorbed energy requirements are met at the lower test temperature.

8.6.2.2.3 Procedure qualification tests shall include at least two macrohardness traverses across the weld, heat-affected zones and parent metal, as shown in Figure 8-1.

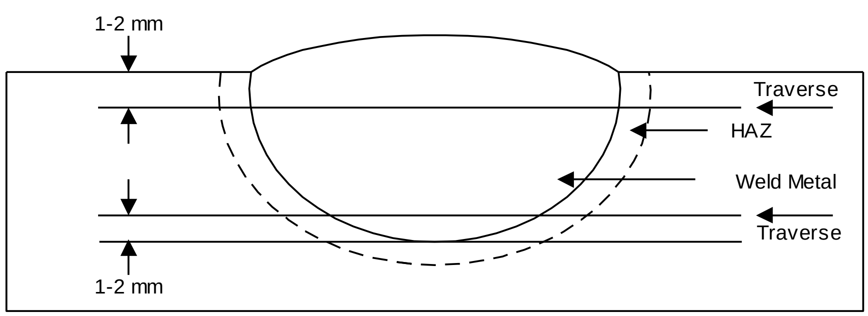


Figure 8-1: Macrohardness Traverse

8.6.2.2.4 Macrohardness testing shall be conducted in accordance with, and shall meet the applicable requirements of, Clauses 8.6.1.5, 8.6.1.6 and 8.6.1.7 of this Specification.

8.6.2.2.5 If the repair welding procedures to be used have not previously been accepted by the Company in writing, they shall be submitted for review and written acceptance by the Company.

8.10 Coil/Plate End Welds

8.10.1.1 Coil/plate end welds (or skelp end welds) shall not be acceptable for finished SAWH pipe unless otherwise specially agreed.

8.11 Jointers

8.11.2 It shall be acceptable to furnish mill jointers, subject to the requirements of Annex A of API 5L and to the requirements of this Specification. Welding shall be completed with the double submerged arc welding process.

8.11.5 Welds containing defects shall be repaired in accordance with the requirements of Clause 8.6.2 of this Specification, or cut out as a cylinder and rejected. Repair of repairs shall not be permitted.

8.11.6 Welding procedures shall meet the requirements of Clause 8.6.1 of this Specification.

8.11.7 Transverse Weld Tensile Tests – Jointer Welds

8.11.7.1 For circumferential mill jointer welds, tests shall be conducted on the first weld and the tenth weld for each diameter and each wall thickness to verify the welding process. Thereafter, tests shall be conducted at a frequency of one test per lot of 500 welds for each diameter and each wall thickness, and shall meet the minimum ultimate tensile strength requirements of Table 7 of API 5L for the applicable pipe grade.

8.11.8 Guided Bend Tests – Jointer Welds

8.11.8.1 For circumferential mill jointer welds, face and root guided-bend tests shall be conducted on the first weld and the tenth weld for each diameter and each wall thickness to verify the welding process. Thereafter, tests shall be conducted at a frequency of one test per lot of 500 welds for each diameter and each wall thickness in accordance with, and to meet the requirements of, Clause 9.7 and Clause 10.2.3.6 of API 5L.

8.11.9 Fracture Toughness Tests – Jointer Welds

8.11.9.1 For circumferential mill jointer welds, tests shall be conducted on the first weld and the tenth weld for each diameter and each wall thickness to verify the welding process. Thereafter, tests shall be conducted at a frequency of one test per lot of 500 welds for each diameter and each wall thickness, and shall meet the requirements of Table 9-3 of this Specification.

8.11.10 Single-Jointers

8.11.10.1 If approved by the Company, it shall be permissible to furnish single-jointers (two pieces welded together to make a length shorter than 15.0 m (49.2 ft.)) to a maximum of 5% of each order item.

8.11.11 Double-Jointers

8.11.11.1 If approved by the Company, it shall be permissible to furnish double-jointers (two pieces welded together to make a length 15.0 m (49.2 ft.) or longer) for an entire order or any portion thereof.

8.11.12 Triple-Jointers

8.11.12.1 If approved by the Company, it shall be permissible to furnish triple-jointers (three pieces welded together to make a length 15.0 m (49.2 ft.) or longer) to a maximum of 5% of each order item.

8.13 Traceability

8.13.2.1 The Quality Assurance program in effect shall provide documentation that allows traceability of the skelp rolling practices, and heat, slab and coil used for each pipe section. If this documentation cannot be supplied, the Company will treat each coil produced during a particular mill work shift as being from a different heat and the frequency of testing shall be increased accordingly.

8.14 Manufacturing Procedure Specification (MPS)

8.14.1 As part of the quotation for the supply of line pipe under this Specification, the Manufacturer shall submit a Manufacturing Procedure Specification (MPS) document providing the information including, but not limited to, that listed in B.3.1 of Annex B of this Specification. The MPS shall be approved by the Company in writing prior to the commencement of production. Any subsequent changes to the approved Manufacturing Procedure Specification shall be approved by the Company in writing prior to implementation.

8.14.2 In addition to the MPS, the Manufacturer shall submit a document that clearly cross-references the locations in the MPS where the requirements outlined in B.3.1 of Annex B and in Clause E.5.8 of this Specification can be found.

9 ACCEPTANCE CRITERIA

9.2 Chemical Composition

9.2.2 Heat analysis and product analysis shall conform to the chemical composition limits specified in Table 9-1 of this Specification. The weight percent for all elements shall be provided to the same number of decimal points as shown in Table 9-1.

Table 9-1: Chemical Composition Limits

		Pipe Grades ≤ L485M (X70M)	Pipe Grades > L485M (X70M)
Element	Symbol	Maximum % (unless a range is specified)	Maximum % (unless a range is specified)
Carbon	C	0.10, see Restriction A	0.10, see Restriction A
Manganese	Mn	1.75 for L415M & L450M, see Restriction A 1.90 for L485M, see Restriction A	2.00, see Restriction A
Phosphorus	P	0.020	0.020
Sulphur	S	0.010	0.008

		Pipe Grades ≤ L485M (X70M)	Pipe Grades > L485M (X70M)
Element	**Symbol**	**Maximum % (unless a range is specified)**	**Maximum % (unless a range is specified)**
Silicon	Si	0.40	0.40
Niobium (Columbium)	Nb (Cb)	0.100 for L360M to L485M, see Restrictions B & C	0.100, see Restrictions B & C
Vanadium	V	0.090 for L360M to L485M, see Restrictions B & C	0.090, see Restrictions B & C
Titanium	Ti	0.004 - 0.030 for L360M to L485M, see Restriction C	0.004 - 0.030, see Restriction C
Aluminum	Al	0.010 min, 0.060 max (ASA†)	0.010 min, 0.060 max (ASA†)
Aluminum	Al	0.020 min, 0.120 max (total†)	0.020 min, 0.120 max (total†)
Nitrogen	N	0.014	0.014
Copper	Cu	0.40	0.40
Chromium	Cr	0.30, see Restriction A	0.30, see Restriction A
Molybdenum	Mo	0.30, see Restriction A	0.40, see Restriction A
Nickel	Ni	1.00	1.00
Calcium	Ca	0.0050	0.0050
Cerium	Ce*	No deliberate additions	No deliberate additions
Boron	B	0.0010, no deliberate additions	0.0010, no deliberate additions
Carbon Equivalent **	CE (*Pcm*)	0.200	0.220

		Pipe Grades ≤ L485M (X70M)	Pipe Grades > L485M (X70M)
Element	Symbol	Maximum % (unless a range is specified)	Maximum % (unless a range is specified)

Notes:

* For facilities not having the capability of analyzing for Ce, it is sufficient to report as "No deliberate additions"

** The carbon equivalent shall be calculated in accordance with the requirements of Clause 9.2.4 of API 5L.

† Either the acid soluble aluminum (ASA) or total aluminum content shall be determined. It is not necessary to determine both values. The minimum limits on Al may be adjusted for Ti-killed and vacuum-degassed steels, in which case an appropriate minimum limit on Ti content will be required instead. Manufacturers wanting to use Ti-killed steels shall clearly identify their intention and proposed Ti limits prior to production.

Restrictions:

Restriction A: See Table 9-2

Restriction B:

V + Nb : 0.12 max for L415M to L690M

Restriction C:

V + Nb + Ti : 0.15 max for L415M to L690M

Table 9-2: Restriction A

Carbon Content	Mn Max for L415M & L450M (X60M & X65M)	Mn Max for L485M (X70M)	Mn Max for >L485M (X70)	(Mn+Cr+Mo) Max for L415M to L485M (X60M to X70M)	Mn+Cr+Mo) Max for L415M to L485M
≥ 0.09	1.50	1.60	1.75	1.95	2.15
0.08	1.55	1.65	1.80	2.00	2.20
0.07	1.60	1.70	1.95	2.02	2.35
0.06	1.65	1.75	1.95	2.07	2.35
0.05	1.70	1.85	2.00	2.20	2.40
≤ 0.04	1.75	1.90	2.00	2.25	2.40

Note:

Carbon values intermediate to those listed (i.e., C=0.085) shall be rounded in accordance to ASTM E29.

9.3 Tensile Properties

9.3.2 The tensile properties shall be as given in Table 7 of API 5L, and as outlined in this Specification.

9.3.2.1 The ratio of yield strength to tensile strength (Y/T) for transverse body tensile tests shall not exceed 0.90 for grades ≤L555M (X80M), and shall not exceed 0.93 for L625M (X90M). The ratio of Y/T shall not exceed 0.93 for L690M (X100M) when testing with flattened strip specimen and shall not exceed 0.95 for L690M (X100M) when testing with other than flattened strip specimen.

9.3.2.2 For transverse weld tensile tests, the ultimate tensile strength shall be as given in Table 7 of API 5L.

9.3.2.3 For transverse weld tensile tests of longitudinal, helical, skelp end and circumferential mill jointer welds, the elongation in 50 mm (2 in.) shall be 10% or more.

9.8 CVN Impact Test for PSL 2 Pipe

9.8.2 Pipe Body Tests

9.8.2.1 Pipe shall be tested at the frequencies specified in Table 18 of API 5L as amended by this Specification, and shall meet requirements outlined in Table 9-3 of this Specification, at or lower than the pipe test temperature specified on the purchase order.

9.8.2.2 For all pipe sizes, the fracture appearance as determined by a Charpy V-notch impact test shall exhibit a fracture appearance shear area of 85% minimum for any test, with no individual test specimen exhibiting less than 75% shear area, at or lower than the test temperature outlined on the purchase order.

9.8.3 Pipe Weld and HAZ Tests

Charpy V-notch impact tests shall be conducted on test specimens taken from the deposited weld metal and heat affected zone, and shall meet requirements outlined in Table 9-3 of this Specification. Samples from longitudinal, helical, skelp-end and circumferential welds, whichever are applicable, shall be selected by the Manufacturer, except that the Company reserves the right to select additional samples. Pipe test temperature shall be the same as that for the notch toughness tests in the body of the pipe.

9.8.3.1 The test frequency shall be the same as required for weld tensile tests.

Table 9-3: Minimum Full Size Charpy V-Notch Absorbed Energy in J (ft. lbs)

		Minimum Full Size Charpy V-Notch Absorbed Energy in J (ft. lbs)[7]			
		Pipe Body		Weld and HAZ	
Overall Design Factor[1]	Pipe Size in mm O.D. (NPS)	Any Heat[2,3]	All Heat Average[2,4]	Longitudinal Seams[5]	Helical, Skelp End, and Circumferential Seams[5]
> 0.60	1219 (48)	75 (55)	155 (114)	75 (55)	55 (41)
> 0.60	1067-1811 (42-46)	65 (48)	145 (107)	65 (48)	50 (37)

		Minimum Full Size Charpy V-Notch Absorbed Energy in J (ft. lbs)[7]			
		Pipe Body		Weld and HAZ	
Overall Design Factor[1]	Pipe Size in mm O.D. (NPS)	Any Heat[2,3]	All Heat Average[2,4]	Longitudinal Seams[5]	Helical, Skelp End, and Circumferential Seams[5]
> 0.60	914-1016 (36-40)	55 (41)	130 (96)	55 (41)	40 (30)
> 0.60	610-864 (24-34)	45 (33)	110 (81)	45 (33)	35 (26)
> 0.60	457-559 (18-22)	40 (30)	90 (66)	40 (30)	30 (22)
> 0.60	406.4 (16)	27 (20)	55 (41)	27 (20)	27 (20)
≤ 0.60	≥ 457-1219 (18 – 48)	40 (30)	55 (41)	40 (30)	30 (22)
≤ 0.60	406.4 (16)	27 (20)	40 (30)	27 (20)	27 (20)

Notes (Normative):

[1] The overall design factor will be specified on the purchase order and the request for quote. In Canada, the overall design factor equals the design factor multiplied by the location factor.

[2] Pipe Body "Any Heat" and "All Heat Average" values are based on specific design conditions, including a grade ≤ L485M (X70M) and a maximum design pressure of 10,000 kPa (1450 psi). If the grade exceeds L485M (X70M) and/or the design pressure exceeds 10,000 kPa (1450 psi), the values shall be re-assessed by the Company and higher values may be specified. Higher values may also be specified for special design conditions (e.g., rich gas or lower design temperatures).

[3] Shear area from Charpy testing shall be reported for pipe larger than 457 mm (NPS 18) for information only.

[4] The "All Heat Average" requirement is recommended, but is not mandatory, for pipe ordered for liquid hydrocarbon pipeline systems and does not apply to pipe for orders filled by the production of less than five heats.

[5] Shear area from the weld and HAZ shall be reported for information only.

[6] The values listed in this Table are suitable for natural gas pipelines designed using the alternate design factors permitted by 49 CFR 192 up to the limits listed in Note 2.

[7] The values in ft. lbs are converted from the values in J.

[8] For pipe wall thickness ≥19.1 mm (0.75 in.), additional testing shall be conducted on mid-wall samples.

9.9 DWT Test for PSL 2 Welded Pipe

9.9.1.1 For pipe larger than 457 mm O.D. (NPS 18), the fracture appearance as determined by a drop-weight tear test shall exhibit a shear area of 85% minimum for any test, with no individual test specimen exhibiting less than 75% shear area, at or lower than the test temperature outlined on the purchase order.

9.10 Surface Conditions, Imperfections and Defects

9.10.4 Laminations

Laminations of any size extending into the face or bevel of the pipe shall be classified as defects. Pipes that contain such defects shall be rejected or cut back until no such lamination is present at the pipe ends.

9.10.5 Geometric Deviations

9.10.5.1 Geometric deviations, other than dents, from the normal cylindrical contour of the pipe (e.g. flat spots and peaks) that occur as a result of the pipe forming process or manufacturing operations, and that exceed 2.0 mm (0.08 in.) in depth or height measured as the gap between the extreme point of the deviation and the prolongation of the normal contour of the pipe, shall be considered defects and treated in accordance with C.3 b) or C.3 c) of API 5L.

9.10.5.2.1 Dents that are 6.4 mm (0.25 in.) or less in depth and contain stress concentrators shall be considered defects and shall be cut out as cylinders and rejected or shall be repaired by grinding to remove stress concentrators, provided that the remaining wall thickness is within the specified limits.

9.5.10.2.2 Dents of any depth that intersect the longitudinal weld seam shall be considered defects and removed from the pipe as a cylinder.

9.10.5.3 Flat Spots and Peaks

9.10.5.3.1 The end of the pipe in the vicinity of the weld shall be checked with a template contoured to check for flat spots and peaks along both the ID and OD, to ensure a maximum deviation of no greater than 2.0 mm (0.08 in.), excluding any out-of-roundness.

9.10.5.4 Belling and Crimping

9.10.5.4.1 The ends of the pipe shall be checked for crimping and belling using a procedure that is accepted in writing by the Company.

9.10.6 Hard Spots

Any hard spot larger than 50 mm (2.0 in) in any direction shall be classified as a defect if its hardness exceeds 300 HV10, based upon individual indentations.

9.10.7 Other Surface Imperfections

Other surface imperfections found by visual inspection shall be investigated, classified and treated in accordance with Clause 9.10.7 of API 5L and as follows:

a) Surface scores (sharp notches, gouges, scores, slivers, pits, etc.) and all stress raising imperfections shall be removed by grinding even though they may be less than the maximum depth permissible for imperfections.

c) Any OD or ID imperfection having a depth that results in a remaining wall thickness at any point of less than 95% of the specified nominal wall thickness shall be considered a defect.

d) The external pipe surface shall be suitable for coating with fusion bond epoxy and polyethylene. Pipe shall have an internal surface suitable for coating with liquid epoxy. Slivers, scabs, bristles or other surface imperfections that would result in an unacceptable applied internal or external coating shall be considered defects and shall be removed by grinding.

9.10.7.1 Grinding

9.10.7.1.1 The minimum remaining wall thickness at any point after grinding shall not be less than 95% of the nominal ordered thickness.

9.11 Dimensions, Mass and Tolerances

9.11.3 Tolerances for Diameter, Wall Thickness, Length and Straightness

9.11.3.1.1 Diameter

9.11.3.1.1.1 Tolerances for diameter of the pipe body and for diameter of the pipe ends shall be in accordance with requirements of Table 10 of API 5L, except that the diameter tolerances shall not exceed plus or minus 2.0 mm (0.08 in.) at any location along the length of the pipe.

Unless otherwise agreed, the diameter of each pipe joint shall be measured at each end (within 100 mm or 4 in.) plus three equally spaced intervals along the pipe body after hydrostatic test.

9.11.3.1.2 Out-of-Roundness

9.11.3.1.2.1 For all pipe sizes and D/t ratios, the maximum difference between the lengths of the major and minor axes at any point along the pipe shall be in accordance with the requirements of Table 10 of API 5L, with the additional requirement that in no case shall the maximum difference between the lengths of the major and minor axes at any point exceed 12.7 mm (0.500 in.).

9.11.3.2 Wall Thickness

9.11.3.2.1 The minimum wall thickness at any location shall be 95% of the specified wall thickness.

9.11.3.2.2 The average wall thickness for the quantity on the purchase order when five or more heats are provided shall not be less than the specified wall thickness. It shall be permissible to establish compliance with this requirement on the basis of mass.

9.11.3.3 Length

a) The minimum length, minimum average length and maximum length shall be identified on the quotation by the Manufacturer and shall be subject to prior agreement by the Company.

9.11.3.4 The tolerances for straightness shall be as per requirements in API 5L and as per the following:

a) The local deviation from a straight line in the 1,000 mm (39 in.) portion at each pipe end shall be less than or equal to 2 mm (0.08 in.).

9.12 Finish of Pipe Ends

9.12.5 Plain Ends

9.12.5.2 Where field welding is to be conducted with other than a mechanized process, pipe shall be furnished with a root face dimension of 1.6 mm (0.063 in.), +0.8 mm (0.031 in.), - 0.0 mm (-0.0 in.) for a minimum of 95% of the circumference around each field end.

9.12.5.2.1 For orders of station pipe, pipe shall be furnished with a root face dimension as per the requirements of API 5L.

9.13 Tolerances for Weld Seam

9.13.1 Radial Offset of Strip/Plate Edges

9.13.1.1 The maximum offset for all wall thicknesses and at any location in the pipe shall be 10% of the specified wall thickness.

9.13.2 Height of the Weld Bead Reinforcement

9.13.2.2 d) The outside weld bead shall not extend above the adjacent pipe surface by more than 3.5 mm (0.138 in.) for specified wall thickness ≤ 13.0 mm (0.512 in.) and 4.0 mm (0.157 in.) for specified wall thickness > 13.0 mm (0.512 in.).

e) For pipe of size 610 mm OD (NPS 24) and larger with an overall design factor greater than 0.50, both ends of the pipe shall have the outside weld reinforcement removed for a distance of at least 150 mm (6.0 in.) from the end of the pipe, such that the outside weld bead does not extend above the outside surface of the pipe by more than 0.1 mm (0.004 in.). The minimum remaining wall thickness at any point after removal of the weld reinforcement shall be in accordance with the requirements of Clause 9.10.7.1 of this Specification.

9.13.4 Offset of Adjoining Lengths of Pipe in Welded Jointers

9.13.4.1 The maximum allowable offset (high-low) between the outside surfaces of adjoining lengths of pipe shall be 2.5 mm (0.100 in.).

9.15 Weldability of PSL 2 Pipe

9.15.1 Weldability tests shall be conducted in accordance with and shall meet the requirements of the *WIC-1 Testing Procedure Specification* in Annex Q of this Specification. Weldability tests are required when the pipe is Grade L415M (X60M) or higher. Weldability tests shall not be required for station pipe orders.

9.15.2 Weldability tests shall be repeated when any of the following conditions occur:

a) the carbon equivalent, calculated in accordance with the requirements of Clause 9.2.4 of API 5L, increases by more than 0.03 from the previously accepted test result

b) the specified wall thickness increases more than 10% within one of the ranges specified in the following note

Note:

There are two wall thickness ranges:

i. < 7.3 mm (0.288 in.)

ii. ≥ 7.3 mm (0.288 in.)

c) the grade increases from the previously accepted test results

d) the steelmaking practice changes

e) the steel Manufacturer or the location of the steel mill changes

f) when a new heat is provided, until a total of three heats have been tested and have been found to meet the requirements of Annex Q of this Specification

9.15.3 Provided that the requirements of Clause 9.15.2 of this Specification are met, successful WIC tests submitted as part of a previous order may be used to satisfy the requirements of a current order.

9.15.4 If more than one of the three test welds in a heat fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected. If one of the three test welds on any heat fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected or two additional test welds from the same heat shall be taken. If either of the two additional test welds fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected.

9.15.5 When a heat is rejected, two additional heats of steel shall be tested. If either of these additional heats is rejected, the acceptance of every heat of steel for the order shall be subject to agreement by the Company.

9.16 Hardness

9.16.1 The maximum macrohardness shall be 280 HV using a load of 10 kg, when conducted in accordance with the requirements of ASTM Standard E92.

10 INSPECTION

10.1 Types of Inspection and Inspection Documents

10.1.3 Inspection Documents for PSL 2 Pipe

10.1.3.1 The Manufacturer shall supply material test and certification documents in a format approved by the Purchaser and in accordance with requirements of this Specification.

10.1.3.2 In addition to the information to be provided in accordance with Clause 10.1.3.2 of API 5L, the following additional information shall also be provided:

b) Chemical composition (heat and product) and acceptance criteria for all elements referenced in Table 9-1 of this Specification, carbon equivalent (heat analysis and product analysis) and acceptance criteria. Additionally, the values of all restrictions listed in Table 9-1 of this Specification shall be reported.

c) Mechanical test results, including results for body tensile tests (including Y/T ratio), transverse weld tensile tests, guided-bend tests, notch toughness tests and macrohardness tests, and heat number and qualification pipe number for each test. For guided-bend tests, it shall be permissible to supply certification that the tests were completed.

d) CVN impact test results, the size, orientation and location of the test pieces; the source (pipe body or weld), type (flattened or unflattened), individual and average test results for each test, heat number and qualification pipe number for each test, and acceptance criteria for each CVN test.

e) DWT test results, type of specimen (flattened or unflattened), type of notch (pressed or chevron), individual and average test results for each test, heat number and qualification pipe number for each test and acceptance criteria for each DWT test.

m) The results of weld zone metallographic examinations (it shall be permissible to supply a certificate that the tests were done in accordance with, and met the requirements of, this Specification in lieu of actual test results).

n) The results of all hardness tests.

o) Steelmaking method, steelmaking practice number, deoxidation practice and casting method.

p) Rolling practice number and the type of skelp rolling mill used.

q) Expansion factor for cold-expanded pipe.

r) Purchase order number.

s) Certification that non-destructive inspection was performed in accordance with, and met the requirements of Clause 10.2.10 of this Specification and Clause 10.2.10 of API 5L.

t) A correlation of heat numbers to pipe numbers for all pipe applied to the order.

u) Certification that the pipe has been manufactured in accordance with the requirements of API 5L and this Specification and/or dual certification to CSA Z245.1, if specified.

10.1.3.3 Pipe shall not be considered for acceptance until two copies of the reports and test certificates required by Clause 10.1.3.2 of this Specification are provided.

10.1.3.4 In addition to the reports and test certificates supplied with the pipe shipments, the final certification documents shall be submitted within two weeks of completion of production. Two paper copies and one searchable electronic copy are required.

10.2 Specific Inspection

10.2.1 Inspection Frequency

10.2.1.2 The inspection frequency shall be as given in Table 18 of API 5L, and as outlined in this Specification.

10.2.1.2.1 Transition Curves

From 5% of the heats supplied for pipe ordered for each diameter, wall thickness and grade, the Manufacturer shall provide and include as applicable with the inspection documents, notch toughness transition curves for pipe body parent material, deposited weld metal and heat affected zone. A minimum of one set of transition curves shall be provided for pipe of each diameter, wall thickness and grade. The documents shall report CVN impact test specimen size, actual test values in tabular form, and shall also include values for absorbed energy and fracture appearance as applicable, plotted in graphical form to clearly illustrate plateau energies and transition temperatures. For orders where the DWT test is a requirement, full transition curves for both shear area (based on DWT data) and energy absorption (based on CVN test data) shall be provided.

Transition curves shall not be required for pipe orders where the specified test temperature is -45 °C, such as station pipe for applications in Canada.

10.2.1.2.2 Hardness Testing

Hardness testing of the deposited weld metal, heat affected zone and parent material shall be performed on prepared cross-sections at locations as outlined in Clause 8.6.1.5 of this Specification. Test frequencies shall be as follows:

a) For longitudinal and helical welds: one test per production welding day per OD welder, and at least once for each heat of material supplied for an order.

b) For skelp end welds: one test per 50 lengths containing skelp end welds.

c) For circumferential mill welds: one test per lot of 500 welds.

Tests shall be conducted in accordance with the requirements of Clause 9.16.1 of this Specification.

10.2.3 Samples and Test Pieces for Mechanical Tests

10.2.3.1.1 Samples and test pieces for mechanical tests (tensile tests, CVN tests and DWT tests) that are conducted at the frequency specified in Table 18 of API 5L and

Clause 10.2.1 of this Specification shall be taken from the same end of the same length of pipe that is sampled for testing.

10.2.3.2 Test Pieces for Tensile Test

10.2.3.2.1 The use of round test specimens shall be restricted to Grade L555M (X80M) and higher, and shall be subject to agreement by the Company.

10.2.3.2.2 Weld reinforcement shall not be removed from weld tension test specimens.

10.2.4 Test Methods

10.2.4.2.1 For pipe weld tests, the percentage elongation after fracture shall be determined.

10.2.6 Hydrostatic Test

10.2.6.1 The test pressure shall be held constant for a duration of not less than 10 seconds.

10.2.6.2.1 The individual pressure recordings shall be unambiguously traceable to each pipe number and heat number.

10.2.6.5.1 The pressure of the hydrostatic test medium shall stress the pipe wall to at least 95% of the Specified Minimum Yield Strength (SMYS).

10.2.6.6 Any proposals to determine test pressure by applying end load compensation in accordance with Equation (7) of API 5L shall be indicated at the time of submission of proposals for supply. The hoop stress induced by the hydrostatic pressure as calculated by Equation (6) of API 5L (i.e., without end load compensation) shall be at least 90% SMYS.

10.2.6.7 The required test pressure shall be determined using the specified nominal wall thickness, *t*.

10.2.6.8 Hydrostatic gauges are to be calibrated prior to commencement of production of pipe of each diameter, wall thickness and grade, at least weekly thereafter, and after all hydrostatic test failures.

10.2.6.9 Each hydrostatic test failure shall be investigated, and the cause of each failure determined and fully documented. The failure investigation results shall be forwarded to the Company. This requirement shall not apply if the pipe being hydrostatically tested was rejected prior to the hydrostatic test.

10.2.7 Visual Inspection

10.2.7.1 All pipe shall be subjected to visual inspection over the entire internal and external surfaces in accordance with requirements of Clause 10.2.7.1 of API 5L and also in accordance with Clause 10.2.7.1.2 of this Specification.

10.2.7.1.1 The external and internal surfaces of the pipe shall be presented for final visual inspection free of oil, grease, lubricant, flux, loose mill scale or other foreign matter.

10.2.7.1.2 Visual inspection shall include, but not be limited to, the following:

a) The entire external surface by an inspector walking the full length of the pipe.

b) The internal surface by an inspector crawling the pipe, except that pipe smaller than 762 mm OD (NPS 30) may be internally inspected from the ends using suitable inspection lamps.

c) The pipe ends.

10.2.8 Dimensional Testing

10.2.8.3 For pipe larger than 457 mm OD (NPS 18), it shall be permissible for the tolerances on outside diameter of the pipe to be applied to the inside diameter.

10.2.10 Non-Destructive Inspection

Non-destructive inspection shall be in accordance with Annex E of both API 5L and this Specification.

10.2.12 Retesting

10.2.12.6 Charpy retests

10.2.12.6.1 For CVN impact tests on pipe welds and heat affected zones, failure of any test shall require two additional tests; one on the pipe immediately before the failed pipe and the second on the pipe immediately after the failed pipe. The pipe tested shall be from the same OD welding station and have been welded using the same welding procedure. If both tests conform to the requirements, the pipe in the lot shall be accepted, except that pipe from which the initial test was taken. If one or both tests fail to meet the requirements, all pipe in the lot shall be individually tested and each pipe shall meet the specified requirements or the Manufacturer may reject the lot. To qualify the original failed pipe, if both retests pass, the Manufacturer shall take an additional test from each end and the specified requirements shall be met.

10.2.12.7 Hardness retests

10.2.12.7.1 In the event of a hardness test failure, a documented proposal for the location and number of retests shall be prepared by the Manufacturer and submitted for approval by the Purchaser.

10.2.12.7.2 The results of all hardness tests shall be reported.

11 MARKING

11.2 Pipe Markings

11.2.1 Pipe markings shall include the following information in addition to that required by Clause 11.2 of API 5L, and when specified, in addition to that required by Clause 15.2 of CSA Z245.1, latest revision:

k) the pipe number as applied to the ID and OD of each pipe at both ends

l) the heat number (or code traceable to the heat number) as applied to the I.D. at both ends of each pipe

m) the purchase order number as applied to the ID and OD at both ends of each pipe

n) for mill-jointers, the following marking as applied to the ID and OD of each jointed section at both ends:

- Top line: jointer segment pipe no. nearest observer
- Middle line: middle jointer segment pipe no., if applicable
- Bottom line: jointer segment pipe no. farthest away from observer.

11.2.3 Die-stamping and/or vibro-etching shall not be permitted on the inside or outside surface of the pipe.

11.2.4 If agreed, the pipe markings as required on the OD of the pipe may be applied after subsequent coating application. In such case, the pipe markings on the ID of the pipe, as required per this Specification and approved for the project, shall be completed before coating application and traceability shall be ensured.

11.2.8 Additional markings applied shall be at the approval of the Company.

11.2.9 All markings required by API 5L, the purchase order number, heat number (or code traceable to the heat number) and pipe number shall be marked on the inside and/or outside surface of the pipe in accordance with Table 11-1 of this Specification.

Table 11-1: Location of Markings

Pipe Size in mm O.D. (NPS)	API Marking and Heat Code	Pipe	PO Number
All sizes	ID	ID and OD	ID and OD

The heat code, purchase order number and pipe number shall be placed at both ends of each length of pipe.

Figure 11-1 and Table 11-2 of this Specification provide further detail on where markings should be placed.

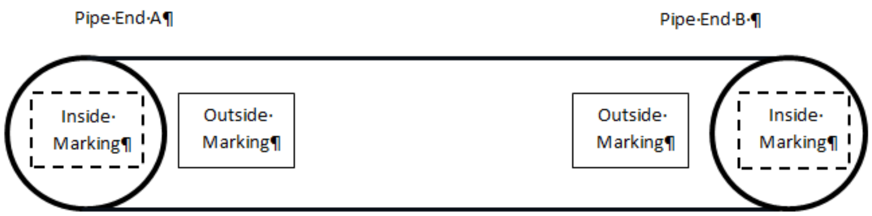


Figure 11-1: Location of Pipe Markings

Table 11-2: Specific Location of Pipe Markings

Pipe Size in mm O.D. (NPS)	Pipe End A		Pipe End B	
	Outside Marking	Inside Marking	Outside Marking	Inside Marking
All sizes	1. Pipe Number 2. PO Number	1. API 5L Clause 11 requirements 2. Pipe Number 3. PO Number	• Pipe Number • PO Number	1. Heat Code 2. Pipe Number 3. PO Number

12 COATINGS AND THREAD PROTECTORS

12.1 Coatings and Linings

12.1.1 Unless otherwise stated on the purchase order, pipe shall be supplied with bare metal finish.

15 ADDITIONAL DOCUMENTATION REQUIREMENTS

15.1 Documentation Requirements

15.1.1 The Manufacturer shall submit to the Company, the following documents within the time period shown:

a) Weldability test results no later than the cargo shipment readiness date (see Clause 9.15 of this Specification).

b) Qualified Welding Procedure Specifications (WPS) with the supporting Procedure Qualification Records (PQR) or a change to such procedures production no later than the cargo shipment readiness date (see Clauses 8.6.1 and 8.6.2 of this Specification).

c) Where applicable and specified, the stress relieving heat treatment qualification test results no later than the cargo shipment readiness date (see Clause 8.3.10 of this Specification).

d) Number of meters (or feet) shipped and number of pipe lengths shipped within five working days after each shipment.

e) For orders of 10 heats or more, product histograms for each of the items listed in Table 15-1 shall be supplied within one month after the completion of production. The minimum, maximum, arithmetic mean (average), median value, number of samples and standard deviation shall be reported clearly either in the histograms or separately. For Items 1 to 15 in Table 15-1, histograms shall be prepared for both the heat analysis and product analysis.

Table 15-1: Items Requiring Product Histogram Documentation

1. Carbon Equivalent	13. Titanium
2. Carbon	14. Aluminum
3. Manganese	15. Nitrogen
4. Silicon	16. Transverse Yield Strength
5. Sulfur	17. Transverse Tensile Strength
6. Phosphorus	18. Yield/Tensile Ratio (Y/T)
7. Copper	19. Transverse Weld Tensile Strength
8. Nickel	20. CVN Absorbed Energy - pipe body
9. Chromium	21. CVN Shear Area - pipe body*
10. Molybdenum	22. DWTT Shear Area - pipe body
11. Vanadium	23. CVN Absorbed Energy - weld metal
12. Niobium	24. CVN Absorbed Energy - HAZ
*As applicable	

f) In addition to the reports and test certificates supplied with the pipe shipments, the final certification documents shall be submitted within two weeks of completion of production. Two paper copies and one non-modifiable searchable electronic copy are required.

15.2 Pre-Production Documentation Requirements

15.2.1 The Manufacturer shall supply the Company, at the time of quotation, with any exceptions or alternatives to this Specification. The minimum length, minimum average length and maximum length shall be identified at the time of quotation by the Manufacturer. In addition, the centerline segregation acceptance level shall be presented.

15.2.2 The Manufacturer shall supply the Company, at the time of quotation, a Manufacturing Procedure Specification (MPS) (see Clause 8.14 of this Specification).

15.2.3 Prior to the commencement of production, the Manufacturer shall submit, or have previously submitted, to the Company the following documents and shall have received written acceptance of such from the Company:

a) Ultrasonic inspection procedures for the skelp or pipe body (see Clause 8.3.2.3 of this Specification).

b) Ultrasonic inspection procedure for the weld (see Clause E.5.8 of this Specification).

c) Radiographic inspection procedures for welds (see Annex E of API 5L).

d) If applicable, an alternative method of measuring flat spots and peaks (see Clause 9.10.5.3 of this Specification).

e) The procedure for measuring crimping and belling (see Clause 9.10.5.4 of this Specification).

f) If applicable, an alternative procedure for removing markings identifying imperfections (see Clause E.3.5.1 of this Specification).

g) Liquid penetrant, magnetic particle or ultrasonic inspection procedures, whichever are applicable, for the pipe ends (see Clause E.3.4.1 of this Specification).

15.2.4 The Manufacturer shall inform the Company in writing of any changes to the above documents and shall obtain the written acceptance of the Company for such changes prior to implementing the changes.

15.2.5 The Manufacturer shall have written procedures for the loading, shipping and storage of pipe. These procedures are to be made available to the Company on request.

16 PURCHASER INSPECTION

16.1 The Manufacturer shall allow free access by the Company or its representative to all steelmaking and rolling mill facilities providing skelp for the pipe order.

16.2 The Company may arrange under separate contract with one or more third-party agencies to conduct supervisory, visual, mechanical, electromagnetic, ultrasonic or other types of inspection in the pipe mill.

16.3 Where requested by the Company, the Manufacturer shall permit the examination of all test records made as a production control during the manufacture of the skelp or pipe.

17 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are listed in Table 17-1, Table 17-2 and Table 17-3. Use the latest document revision, unless otherwise approved by TransCanada.

Table 17-1: Regulatory References

Organization/Document No.	Title
National Energy Board (NEB)	SOR/99-294, *National Energy Board Onshore Pipeline Regulations (NEB OPR)*
NOM-007-SECRE	*Transporte de Gas Natural*
U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) Code of Federal Regulations (CFR)	Title 49 Part 192, *Transportation of Natural Gas by Pipeline: Minimum Safety Standards*
	Title 49 Part 195, *Transportation of Hazardous Liquids by Pipeline*
Various	Other applicable federal, provincial and territorial safety acts and regulations by the authority having jurisdiction

Table 17-2: External Industry References

Organization/Document No.	Title
American Petroleum Institute (API)	5L, *Specification for Line Pipe*
	1104, *Welding of Pipelines and Related Facilities*
American Society for Testing and Material (ASTM)	E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*
	E92, *Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials*
American Society of Mechanical Engineers (ASME)	B31.4, *Pipeline Transportation Systems for Liquids and Slurries*
	B31.8, *Gas Transmission and Distribution Piping Systems*
	BPVC-IX, *Welding and Brazing Qualifications*
Canadian Standards Association (CSA)	Z245.1, *Steel Pipe*
	Z662, *Oil and Gas Pipeline Systems*

Table 17-3: Internal References

Document No.	Title
For this Specification, there are no specific Internal references.	

18 DOCUMENT HISTORY

Rev.		
04	**Description**	**Effective Date**
	Revised document developed as part of Columbia Pipeline Integration.	2017-Aug-01
	Rationale Statement	**Responsible Engineer**
	This document was revised to address the following requirements: • Integration of Columbia Pipeline requirements.	Jessica de Vries, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group, to integrate Columbia Pipeline requirements, and to make it more easily accessible to those who use it.	Jessica de Vries, P. Eng.
03	**Description**	**Effective Date**
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	**Responsible Engineer**
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Jessica de Vries, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group and to make it accessible to those who use it.	Jessica de Vries, P. Eng.

19 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
N/A	This Specification was updated and put into the new template. Changed name from TES-PIPE-SAW to TES-MA-SAWPI-GL following the new naming convention.

20 APPROVALS

APPROVALS		
Originator: Derek Chen, P. Eng. Welding and Materials Engineering	Signature	June 26, 2017 Date
Reviewer: Cindy Guan, P. Eng. Welding and Materials Engineering	Signature	June 26, 2017 Date
Reviewer: Jaclyn Brown, P.E. USGO Integrity Program Services	Signature	6/27/2017 Date
Responsible Engineer: Jessica de Vries, P. Eng. Welding and Materials Engineering	Signature June 26, 2017 Date	June 26, 2017 APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, P. Eng., Manager Welding and Materials Engineering	Signature	June 26, 2017 Date

ANNEX B MANUFACTURING PROCEDURE QUALIFICATION FOR PSL2 PIPE

B.3.1 Manufacturing Procedure Specification (MPS) Requirements

The Manufacturing Procedure Specification (MPS) submitted shall include, at a minimum, the following detailed information:

a) steel source, including steelmaking method, heat size, deoxidation practice, inclusion shape control practices, and casting method

b) aim chemistries, including minimum and maximum limits for intentionally added elements, and maximum limits and typical contents for residual elements, for all elements referenced in Clause 9.2 of this Specification at least, and as applicable to pipe of each diameter, wall thickness and material grade to be made for the order

c) superheat for continuous casting, tundish weight, caster diameter, mold type, cast sequence length, intermix practice between different steel chemistries, typical cast speed for types of line pipe products ordered

d) slab soundness and centerline segregation control, system of segregation rating, sample location in the cast sequence and sampling frequency, sample orientation & size, etching method and acceptance criterion for specific products of the order

e) disposition of 1st and last slab in cast sequence for line pipe products, slab inspection and conditioning, and slab dimensions used for specific products of the order (for plate and/or coil)

f) skelp rolling source, specific rolling and forming practices, including where applicable, typical reduction schedules and associated temperature control ranges, controlled rolling start thicknesses and temperatures, final finishing temperatures, coiling temperatures or accelerated cooling stop temperatures, and facilities for thermo-mechanical controlled rolling and on-line accelerated cooling

g) skelp inspection procedures as applicable

h) details of pipe forming procedures

i) pipe manufacturing location, and any plant limitations on wall thickness, diameter, and material grade

j) typical welding parameters and consumable combinations applicable to longitudinal, helical, skelp end, repairs and circumferential welds

k) a description of the quality organization applicable to steelmaking, casting, skelp rolling and pipe manufacturing facilities, including identification of reporting practices, verification mechanisms to assure product traceability in accordance with the requirements of API 5L, and responsibility for customer contact related to commercial and quality matters

l) a flow chart for pipe manufacturing, finishing and qualification processes

m) normal mill control tolerances, assessment and recording frequencies for all specification dimensions for pipe

n) laboratory test equipment present at the manufacturing plant for testing of material properties for the order

o) all non-destructive inspection procedures utilized for specification compliance and for production control, as applicable to skelp, pipe body and welds

p) method and typical amount of cold expansion, as applicable

q) yard handling, storage and shipping procedures, including drawings of proposed methods of stacking and securing pipe for shipment and method of end protection

r) order-specific Inspection and Test Plan (ITP) for Company review and approval

ANNEX E NON-DESTRUCTIVE INSPECTION FOR OTHER THAN SOUR SERVICE OR OFFSHORE SERVICE

E.1 Qualification of Personnel

E.1.1 ISO 9712 shall be the basis for the qualification of non-destructive inspection personnel (excluding visual inspection). Such personnel shall be re-qualified for any method previously qualified if they have not performed non-destructive inspection in that method for a period exceeding 12 months.

E.1.2 Non-destructive inspection shall be conducted by Level 2 or 3 personnel.

E.1.3 Evaluation of indications shall be performed by Level 2 or 3 personnel.

E.3 Methods of Inspection

E.3.1.4 Longitudinal and helical weld seams shall be inspected for longitudinal and transverse imperfections by an ultrasonic method, or by a combination of ultrasonic and radiographic methods. The complete volume of weld metal and heat-affected zones in the weldment shall be inspected, including the mid-wall for radial imperfections.

E.3.1.5 Skelp end welds shall be inspected for longitudinal and transverse imperfections by an ultrasonic method, a radiographic method, or a combination of ultrasonic and radiographic methods, in accordance with the requirements of API 5L and this Specification. Procedures shall be approved by the Purchaser.

E.3.1.6 The junctions of skelp end welds and helical seam welds (T-joints) shall be inspected by procedures including film radiographic methods approved by the Purchaser.

E.3.1.7 Repair welds shall be inspected by radiographic methods in accordance with Clause E.4 of Annex E of API 5L, or by ultrasonic inspection where required by Clause 8.6.2.1 (i) of this Specification.

E.3.1.8 Circumferential jointer welds produced by double submerged arc welding shall be inspected for longitudinal and transverse imperfections by radiographic methods in accordance with Clause E.4 of Annex E of API 5L, by ultrasonic methods in accordance with requirements of API 5L and this Specification, or by a combination of radiographic and ultrasonic methods. Standards of acceptability for circumferential jointer welds shall be in accordance with the requirements of the latest edition of API 1104.

E.3.1.9 The junctions of jointer welds and other double submerged arc welds shall be inspected by radiographic methods, or by ultrasonic inspection methods approved in writing by the Company. Standards of acceptability for the junctions of jointer welds and other double submerged arc welds shall be in accordance with the requirements of Clause E.4 of Annex E of API 5L, or Clause E.5.5.1.1 of this Specification, whichever is applicable.

E.3.1.10 Ultrasonic inspection of helical and longitudinal weld seams shall be performed after final hydrostatic testing.

E.3.1.11 Fluoroscopic inspection shall not be accepted for Specification compliance in the inspection of the skelp end welds, repair welds, circumferential jointer welds or the junctions of jointer welds.

E.3.4 Pipe End Bevel Inspection

E.3.4.1 The bevel area of all pipe shall be inspected for laminations by an ultrasonic inspection technique. Alternatively, the root face and bevel shall be inspected for laminations by a liquid penetrant or a magnetic particle technique after beveling. The inspection procedure shall be documented and accepted by the Company prior to production.

E.3.5 Removal of Markings

E.3.5.1 Any paint markings applied to the pipe to mark locations where alarm limits were exceeded, or where imperfections were noted, shall be removed or painted over with black paint, after it has been confirmed that a defect is not present. The Manufacturer may submit an alternative procedure for acceptance by the Company in writing if this requirement deviates from their standard practice.

E.4 Radiographic Inspection of Welds

E.4.2.2 The radiographic films used shall be in accordance with ISO 11699-1:2008, class C4 or better or ASTM E1815-08, class I, and shall be used with lead screens.

E.5 Ultrasonic and Electromagnetic Inspection

E.5.2 Ultrasonic and Electromagnetic Inspection Reference Standards

E.5.2.3.1 Reference standards for standardization and inspection sensitivity checks shall contain machined standardization reflectors as follows:

a) 1.6 mm (0.063 in.) radially drilled hole or transverse notch (5.0% of specified wall thickness), in accordance with Table E.7 of API 5L, for application of acceptance limits and for setting of alarm levels applicable to transverse defect inspection

b) 1.6 mm (0.063 in.) radially drilled hole, in accordance with Table E.7 of API 5L, for application of acceptance limits and for setting of alarm levels applicable to longitudinal defect inspection

c) rectangular notches; ID and OD, longitudinal orientation, depth 5.0% of specified wall thickness, dimensional tolerances as specified in Table E.7 of Annex E of API 5L, for the verification that the sound beam for longitudinal defect inspection is being directed perpendicular to the weld line

d) at the start of production, the detection of mid-wall imperfections shall be proven using a 2 mm (0.08 in.) diameter mid-wall standardization reflector

E.5.3 Instrument Standardization

E.5.3.1.1 Any signal suppression and electronic damping implemented for standardization shall be identical to that implemented for inspection of the pipe during production.

E.5.3.1.2 Standardization shall be performed at the start of production, after the inspection sensitivity checks required by Clause E.5.4.1.1 of this Specification, and at the start of inspection after any shutdown of the ultrasonic inspection equipment during production. The inspection equipment shall be adjusted to obtain, from the applicable reference standards used to establish the acceptance limits, signals that are within the gate width and exceed the alarm limit, when the reference standard is scanned in a manner duplicating inspection in the dynamic mode.

E.5.3.1.3 The gate start locations and gate widths shall be validated during calibration by positioning the search units at locations coincident with the extremes of the tracking error, and producing signal amplitude at or above the alarm limit signal produced from the standardization reflector.

E.5.4 Records Verifying System Capability

E.5.4.1 Inspection Sensitivity Checks

E.5.4.1.1 The inspection sensitivity shall be checked at least twice every working shift, prior to any planned shutdown of the ultrasonic equipment during production and at the end of production, using the reference standard containing the machined calibration reflectors specified in Clause E.5.2.3.1. For inspection sensitivity checks, the reference standard shall be run through the ultrasonic equipment at production speed.

E.5.4.1.2 Where the signal obtained from the standardization reflector is more than 3dB lower than the acceptance limit, all pipe inspected after the preceding acceptable standardization shall be re-inspected after re-standardization has been accomplished.

E.5.5.1.1 Acceptance Limits

For inspection of the pipe welds, any imperfection that produces a signal greater than the applicable acceptance limit signal for the applicable radially drilled hole or transverse notch shall be considered to be a defect, and shall be dispositioned in accordance with Clause C.4 of Annex C of API 5L and Clause 8.6.2 of this Specification.

E.5.8 Non-Destructive Inspection Procedure Documentation

All non-destructive final inspection procedures, other than for electromagnetic inspections, shall be submitted to and shall receive written acceptance by the Purchaser prior to implementation.

An ultrasonic procedure shall be submitted to the Purchaser for review and written acceptance prior to the start of production. The procedure shall include, but not be limited to, the following information as applicable to both the production-speed inspection system and to any system used for manual prove-up of noted imperfections:

a) ultrasonic instrument equipment manufacturer(s) and model number(s)

b) standard for verification of linearity as performed on instrumentation

c) a drawing clearly outlining the number of ultrasonic transducers in the system, and the location and position of all of the transducers

d) for each transducer or transducer set in the system, gate width setting for dynamic-mode inspection

e) a drawing clearly outlining the identified area of inspection for each transducer when using the gate settings noted above

f) a drawing or statement clearly outlining the maximum tracking error

g) a drawing clearly outlining the design of the reference standard, with details of the location and orientation of holes and surface notches used for standardization

h) for each of the respective reference indicators, the alarm limit settings applied for each of the applicable transducers or transducer sets

i) the mode of operation of each transducer or pair of transducers (pulse echo, transmit only, or receive only)

j) coupling medium utilized for the system

k) coupling alarm method

l) the shape and dimensions of each transducer

m) nominal search unit frequency for each transducer

n) sound entrance angle for each transmitting transducer

o) pulse repetition rate for each transducer or transducer set

p) maximum production-speed of pipe through the system

q) the marking device utilized and if applicable, the marking method and location of marking on the pipe as related to imperfection location

r) standardization procedure, including frequency for standardizations

s) sensitivity check procedure, including frequency for sensitivity checks

E.7.6 Four readings shall be taken approximately 90° apart around the circumference of each end of the pipe. The average of the four readings shall be ≤ 2.5 mT (25 Gauss), and no one reading shall exceed 3.0 mT (30 Gauss) when measured with a Hall-effect gaussmeter or equivalent values when measured with another type of instrument.

ANNEX Q WIC – 1 – TESTING PROCEDURE SPECIFICATION

Q1.0 SCOPE

Q1.1 This Specification defines the procedures and acceptance criteria for the evaluation of the weldability of line pipe material using the modified WIC test. The modified WIC test is a single pass restrained groove weld produced with cellulosic electrodes and it is used to evaluate the material's susceptibility to hydrogen cracking.

Q1.2 This Specification is applicable to the qualification of carbon and low-alloy steel pipe material.

Q2.0 TESTING PROCEDURE

Q2.1 Test Assemblies

The materials required to fabricate the test assembly shown in Figure Q-1 are listed in Table Q-1. Each assembly shall be fabricated as follows:

The stiffener plate shall be welded to the bottom of the backing plate to prevent joint rotation. The shims shall be located beneath the test sections (Figure Q-2) and the test sections shall be fillet welded to the backing bar with a root gap of 1.5 mm ± 0.5 mm (typical). The restraint fillet welds shall be made using a low hydrogen process and welding shall proceed outwards relative to the weld joint preparation, see Figure Q-3. A distance of 25 mm ± 0.5 mm, centered over the weld joint preparation, shall not be welded to the backing bar, and this constitutes the restraint length. Run-on and run-off tabs shall be used to ensure uniform weld deposition within the test weld. The run-on and run-off tabs shall be tack-welded to the backing plate only.

Q2.2 Number of Test Welds and Preheat

For each heat of steel, a minimum of three acceptable test welds shall be evaluated to determine the cracking percentage at the preheat temperature given in Table Q-2.

Q2.3 Welding Technique

Q2.3.1 All welding shall be performed in the vertical down direction with the test assembly located vertically (ASME Section IX 3G position). Welding can be performed manually; however, extensive practice may be required to achieve uniform travel speeds.

Q2.3.2 Test assemblies shall be uniformly heated in an oven to a temperature slightly higher than the desired preheat temperature. The assembly shall be removed from the oven and the temperature at the bevels monitored using a contact thermocouple. Welding shall begin as the required preheat given in Table Q-2 is reached.

Q2.3.3 Welding shall be performed with the consumables given in Table Q-2.

Q2.3.4 Welding parameters shall be monitored using external instrumentation for all tests. The combination of welding parameters shall be such that the resulting heat input is within the range given in Table Q-2.

Q2.4 Acceptable Test Weld Workmanship

Q2.4.1 WIC test welds shall have a profile that is typical of the cellulosic root bead used for pipeline welding (see Figure Q-4). The weld shall be free of significant geometric flaws which will include the following workmanship discontinuities:

a) incomplete penetration of the root bead

b) incomplete fusion of the root bead

c) porosity and hollow bead

d) coupon misalignment (high-low)

e) weld metal centerline solidification cracks

Q2.4.2 The test weld will be sectioned in accordance with the requirements of Clause Q2.5. The minimum weld throat thickness for each section shall be as given in Table Q-2. Unless the section is free of cracks, variation in the WIC test weld throat thickness for each section shall not exceed twice the actual throat thickness (depth of weld h_w, Figure Q-4). Should any of the examined sections fail to meet the workmanship requirements, the entire weld shall be discarded and replaced with another WIC test weld that meets the workmanship requirements.

Q2.5 Measurement of Total Crack Percentage

The test welds shall be allowed to cool to room temperature and removed from the backing bar 24 hours after welding. If complete cracking occurs through the test weld, the total cracking percentage is 100%. If complete cracking through the weld does not occur, the weld shall be sectioned and examined microscopically for cracking. The weld shall be sectioned at the 1/4, 1/2 and 3/4 positions as shown in Figure Q-4. Faces 1A, 2A, 2B and 3B shall be polished, etched and examined at a magnification, of 100X. The depth of cracking, h_c, and the depth of the weld (actual throat thickness) h_w, shall be determined for each section and the total cracking percentage for each test weld reported as follows:

$$\frac{\sum h_c}{\sum h_w} \times 100$$

Q3.0 ACCEPTANCE CRITERIA

Q3.1 Total Cracking Percentage

No single test weld shall result in a total cracking percentage exceeding the value given in Table Q-2.

Q4.0 REPORTING

A final report shall be completed for each weldability evaluation. The report, to include all the test welds completed for the evaluation, shall contain the following information:

a) material description

b) diameter, wall thickness and grade of the pipe tested

c) heat number

d) steelmaking practice (as identified by a unique practice number), steel manufacturer and location of steel mill

e) mill test chemistry

f) consumable brand name, consumable manufacturer's traceability number (heat number, batch number or both) and the electrode diameter

g) weld parameters (amps, volts, travel speed, and heat input) and preheat

h) crack dimensions and bead dimensions

i) summary of test results

j) test personnel names

k) date and number of report

l) signed certification

Table Q-1: Test Assembly Material Dimensions

Quantity	Material	Dimensions			Comments
		Thickness, t (mm)	Width, w (mm)	Length, l (mm)	
2	Test sections, (material under evaluation)	Thickness to be tested	50±1	150±5	One end prepared with standard bevel of pipe specification and oriented such that the actual test weld is deposited perpendicular to the plate/coil rolling direction or to the longitudinal axis of the pipe.
1	Backing plate, mild steel	19 min.	75 min.	300 min.	
1	Stiffener plate, mild steel	19 min.	75 min.	300 min.	
2	Backing shims, steel	3 min.	50 + 1, -10	140 +1, -20	
2	Run on/off tabs, steel	3 min.	19±5	25 min.	Same thickness as backing shim

Table Q-2: Testing Requirements

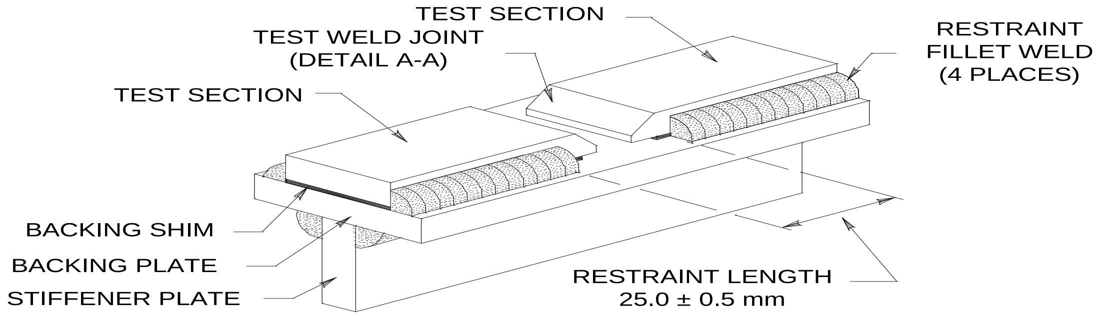
Testing Requirements[2]	Test Sample Nominal Thickness (mm)	
	< 7.3	≥ 7.3
Preheat Temperature (°C)	60±1	75±1
Electrode Classification	E55010-G (E8010-P1)[1]	E55010-G (E8010-P1)[1]
Electrode Diameter (mm)	3.2	4.0
Heat Input (kJ/mm)	0.55 - 0.65	0.65 - 0.75
Typical Welding Parameters	100 - 125 A 23 - 25 V 300 mm/min.	130 - 140 A 22 - 24 V 300 mm/min.
Minimum Weld Throat Thickness of each Section (mm)	2.0	2.5
Maximum Allowable Total Cracking Percentage (%)	5	3

Note(s):

[1] Approved electrodes: Phoenix Cel-80, Lincoln 70+, Bohler Fox Cel 85

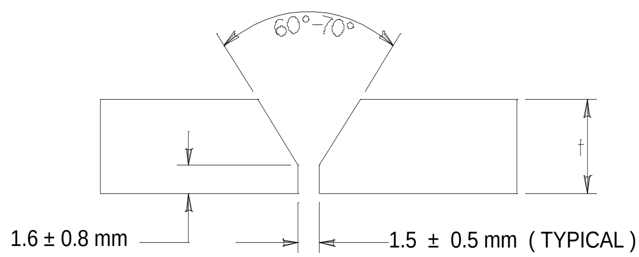
[2] The same supplier, and consumable manufacturer's traceability number (heat number, or batch number or both) shall be used for a series of tests.

CAUTION: Discretion is advised to the Manufacturer and/or test lab that the use of aged electrodes may affect test results.



NOTE:

1. SEE TABLE 1 FOR DIMENSIONS NOT SHOWN.
2. RUN ON/OFF TABS (NOT SHOWN) SHALL BE TACK WELDED TO BACKING PLATE ONLY.
3. BACKING SHIMS ARE PLACED BETWEEN TEST PLATES AND BACKING PLATES.



Test Weld Joint - Detail A-A

Figure Q-1: Modified WIC Test Assembly

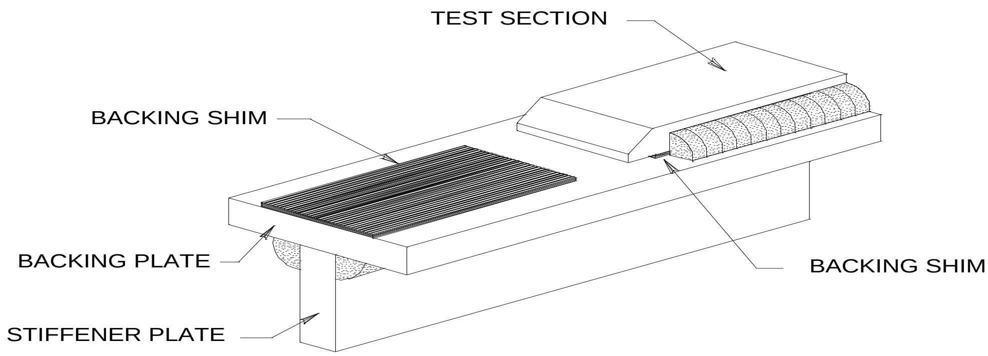


Figure Q-2: Backing Shim Location

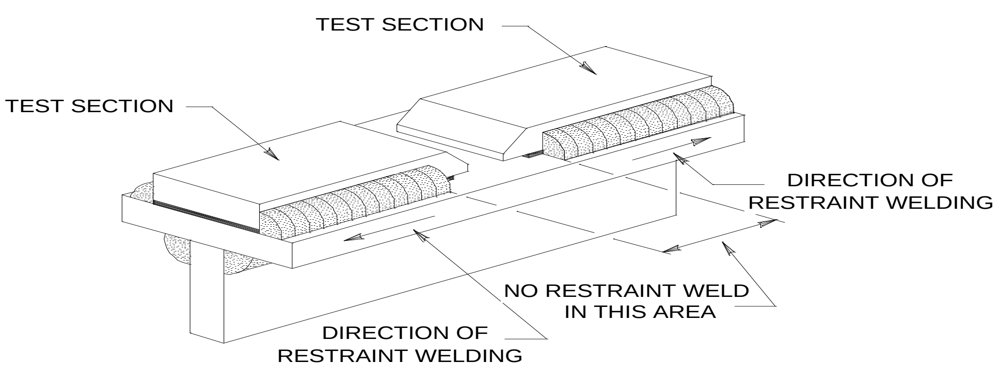
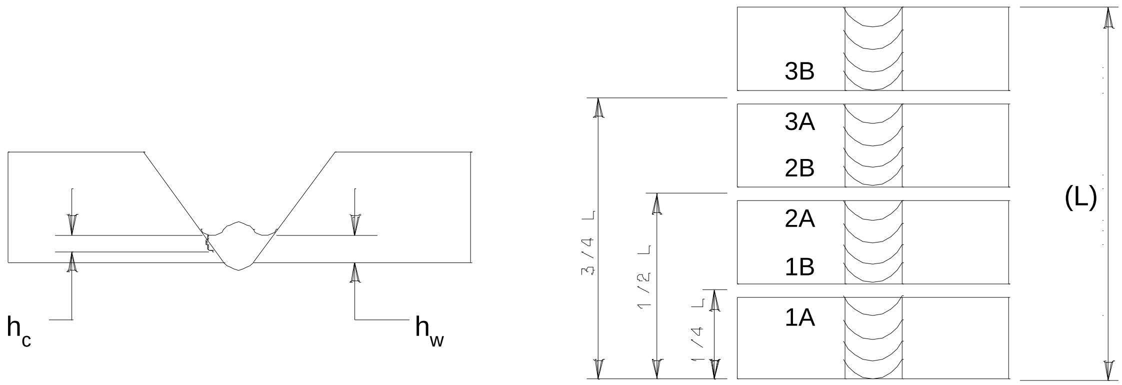


Figure Q-3: Test Section and Restraint Weld Location



NOTE:

1. TEST WELD BEAD SHALL EXHIBIT COMPLETE ROOTPENETRATION AND FUSION.
2. IF h_w IS DIFFERENT ON THE 2 SIDES OF THE WELD USE THE MINIMUM VALUE.
3. (L) - TEST WELD LENGTH
4. h_w- DEPTH OF WELD
5. h_c- DEPTH OF CRACKING

Figure Q-4: Weld Specimen Sectioning

ANNEX R TESTS FOR SUSCEPTIBILITY OF PIPE TO STRESS RELIEVING

R1.0 A sample of pipe shall be stress relieved between 593°C (1100°F) and 649°C (1200°F) for a minimum holding time of 1 hour per 25 mm (1 hour per inch) of thickness, but not less than 1 hour. The temperature shall be recorded on the report supplied to the Company.

R2.0 The same mechanical tests that are required on the pipe that has not been stress relieved shall be conducted on the pipe that has been stress relieved.

R3.0 A report shall be prepared comparing the results of the stress relieved tests to those of the non-stress relieved tests.

Note:

This testing is for information only. The mechanical properties of the stress-relieved pipe may be higher or lower than the non-stress relieved pipe.

R4.0 The tests shall be repeated when there is a change in the steelmaking practice or when pipe of a thicker nominal wall thickness is supplied.

ANNEX S ADDITIONAL DESIGN REQUIREMENTS FOR STEEL PIPE USING ALTERNATIVE MAXIMUM ALLOWABLE OPERATING PRESSURE IN THE USA (AND MEXICO)

S1.0 SCOPE

Natural gas pipelines designed to operate with design factors in excess of those listed in §192.111 of 49 CFR 192 shall meet all of the requirements of this Specification, and the additional requirements of §192.112 of 49 CFR 192 and any amendments or errata issued by the U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration.

This annex outlines the requirements under §192.112 of 49 CFR 192 that are not accounted for in the other Clauses of this Specification.

S2.0 ADDITIONAL REQUIREMENTS

a) Ultrasonic inspection of the ends, and at least 35% of the surface of the plate/coil or pipe to identify imperfections that impair serviceability such as laminations, cracks and inclusions in accordance with ASTM A578/A578M Level B, or Clause 7.8.10 of the 43rd Edition of API 5L as shown currently in §192.112 of 49 CFR 192, or equivalent method, must be carried out on at least 95% of the lengths of pipe manufactured.

b) Centerline segregation shall be monitored by means of a macro etch test or equivalent method on the first or second slab of each casting sequence, and graded with an acceptance criteria of two or better on the Mannesmann scale, or equivalent. Sulphur prints are not an acceptable method for monitoring centerline segregation.

c) Hardness testing using Vickers (HV10), or equivalent test method, shall be conducted on a cross-section of the weld seam of one pipe from each heat plus one pipe from each welding line per day. Each cross-section shall have a minimum of 13 readings (three for each HAZ, three in the weld metal and two in each section of the pipe base metal). The maximum hardness shall be 280 Vickers (HV10), or equivalent.

d) For pipe to be used in a new pipeline segment installed after October 1, 2015, mill hydrostatic test must be conducted at a gauge pressure corresponding to a hoop stress of 95% SMYS without end load compensation.

e) The requirements for minimum full size CVN absorbed energy for the pipe body, weld seams and HAZ shall be specified by the Company in accordance with the requirements of §192.112 of 49 CFR 192 and any amendments or errata issued by the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration. The requirements for absorbed energy may be higher than those specified in Table 9-3 of this Specification.

PURPOSE

This Specification outlines the requirements for the materials, qualification, manufacture, testing and inspection of high frequency electric-welded steel line pipe.

SCOPE/APPLICABILITY

This Specification applies to high frequency electric-welded steel line pipe (as defined in Clause 4.19 and 4.23 of API 5L) purchased for use in the Company's non-sour natural gas and liquid hydrocarbon onshore pipeline systems in Canada, the United States (U.S.) and Mexico.

This Specification applies to pipe with a specified outside diameter (OD) of 273.1 mm O.D. (NPS 10) to 660 mm O.D. (NPS 26). The pipe grade shall not exceed L485M (X70M).

This Specification is to be used in conjunction with the American Petroleum Institute (API) 5L *Specification for Line Pipe*, latest revision. This Specification covers requirements in addition to those of API 5L and any amendment, supplement or errata issued by API. All pipe shall meet, as a minimum, the requirements of API 5L.

The headings and numbering in this Specification correspond to those in API 5L. Where no incremental requirements are given in this Specification, API 5L shall apply as written. If conflict exists between this Specification and the requirements in API 5L, the more stringent of the requirements shall apply.

The Responsible Engineer shall be contacted for clarification if needed.

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GLOSSARY

ASME

American Society of Mechanical Engineers

ASTM

American Society for Testing and Material

CFR

Code of Federal Regulations

Company or Purchaser

TransCanada PipeLines Limited, its corporate affiliate or its agent.

CSA

Canadian Standards Association

DOT

United States Department of Transportation

High frequency electric welded pipe

Electric welded pipe produced with a welding current frequency greater than or equal to 70 kHz.

ISO

International Organization for Standardization

Manufacturer or Vendor

Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.

MSS

Manufacturer Standardization Society

NEB

National Energy Board

NOM

Norma Oficial Mexicana

Purchase order

The purchasing document used to purchase the specified item(s).

Regulatory Authority

The national and/or local regulator having jurisdiction over the facility.

Rolling practice

The rolling parameters, which are within the essential parameters stated, are applied to a steel of specific alloy design to produce a steel having a desired set of physical properties.

Steelmaking practice

The specified chemical composition (including specified tolerances), refining and casting process used in making a heat of solid steel.

Technical Agreement

The document signed by the Company and the Manufacturer that states an agreement on a technical matter.

Welding Procedure

The Welding Procedure Specification, Procedure Qualification Record and all associated non-destructive and destructive test data.

WIC

Welding Institute of Canada

1 SCOPE

1.1 Purpose and Coverage

1.1.1 The requirements of the Annex documents referenced in this Specification, and the applicable Annex documents referenced in API 5L including Addendum documents thereto, shall be met as applicable. When specified, the pipe shall also be certified to meet CSA Z245.1, latest revision.

Pipe shall be supplied to meet the additional requirements outlined on the purchase order documentation or requests for proposal, whichever is applicable.

6 PIPE GRADE, STEEL GRADE, AND DELIVERY CONDITION

6.2 Delivery Condition

6.2.3 All pipe shall, as a minimum, meet the product specification level PSL 2 requirements in regard to API 5L, and Category II in regard to CSA Z245.1, if specified.

6.3 Right of Rejection

6.3.1 Where less than 50% of the pipe length formed from any heat, rolling practice, coil or lot complies with all other requirements of this Specification, the Company reserves the right to reject all pipe from the affected heat, rolling practice, coil, slit or lot. The Manufacturer is responsible for obtaining the Company's written authorization prior to the acceptance of any pipe from such heats, rolling practice, coils, slits or lots.

Note:

Right of rejection shall apply to issues associated with the manufacturing process.

6.4 Welder Qualifications

6.4.1 Pipe supplied for welder qualifications shall be of the highest carbon equivalent of the order.

8 MANUFACTURING

8.3 Starting Material

8.3.2.1 The steel used for the manufacture of pipe shall be micro-alloyed, fine grain, fully killed, continuously cast steel with inclusion shape control. The steelmaking practice shall be identified with a steelmaking practice number.

8.3.2.2 The rolling practice shall be identified with a rolling practice number.

8.3.2.3 All skelp shall be inspected for laminar-type imperfections by a procedure submitted to and accepted by the Company in writing prior to the commencement of production. It shall be permissible to perform the inspection on rolled pipe.

8.3.2.3.1 Any lamination in the body of the pipe or coil shall be considered a defect if its non-destructively determined dimensions exceed both of the following:

a) ≥ 20 mm (0.79 in.) in the circumferential direction; and

b) an area of 7000 mm^2 (10.85 $in.^2$)

8.3.2.4 For all casting methods, the Manufacturer shall have a written method of monitoring the severity of centerline segregation present in either the slab or skelp to minimize the extent of segregation. This method shall be made available to the Company on request. The centerline segregation acceptance level shall be presented as part of the bid documentation.

8.11 Jointers

8.11.1 Supply of jointers shall not be permitted.

8.13 Traceability

8.13.2.1 The Quality Assurance program in effect shall provide documentation that allows traceability of the skelp rolling practices and heat, slab and coil used for each pipe section. If this documentation cannot be supplied, the Company will treat each coil produced during a particular mill work shift as being from a different heat, and the frequency of testing shall be increased accordingly.

8.14 Manufacturing Procedure Specification

8.14.1 As part of the quotation for the supply of line pipe under this Specification, the Manufacturer shall submit a Manufacturing Procedure Specification (MPS) document providing the information including, but not limited to, that listed in B.3.1 of Annex B of this Specification. The MPS shall be approved by the Company in writing prior to the commencement of production. Any subsequent changes to the approved MPS shall be approved by the Company in writing prior to implementation.

8.14.2 In addition to the MPS, the Manufacturer shall submit a document that clearly cross-references the locations in the MPS where the requirements outlined in B.3.1 of Annex B and in Clause E.5.8 of this Specification can be found.

9 ACCEPTANCE CRITERIA

9.2 Chemical Composition

9.2.2 Heat analysis and product analysis shall conform to the chemical composition limits specified in Table 9-1 of this Specification. The weight percent for all elements included in Table 9-1 shall be reported, and shall be provided to the same number of decimal points as shown in Table 9-1.

Table 9-1: Chemical Composition Limits

Element	Symbol	Maximum % (unless range is specified)
Carbon	C	0.10, See Restriction A

Element	Symbol	Maximum % (unless range is specified)
Manganese	Mn	1.55 for L245M to L320M, see Restriction A 1.65 for L360M & L390M, see Restriction A 1.75 for L415M & L450M, see Restriction A 1.90 for L485M, see Restriction A
Phosphorus	P	0.020
Sulphur	S	0.010
Silicon	Si	0.40
Niobium (Columbium)	Nb (Cb)	0.100 for L360M to L485M, see Restrictions B & C
Vanadium	V	0.090 for L360M to L485M, see Restrictions B & C
Titanium	Ti	0.004 - 0.030 for L360M to L485M, see Restriction C
Aluminum	Al	0.010 min, 0.060 max (ASA†)
Aluminum	Al	0.020 min, 0.120 max (total†)
Nitrogen	N	0.014
Copper	Cu	0.40
Chromium	Cr	0.30, see Restriction A
Molybdenum	Mo	0.30, see Restriction A
Nickel	Ni	1.00
Calcium	Ca	0.0050
Cerium	Ce*	No deliberate additions
Boron	B	0.0010, no deliberate additions
Carbon Equivalent **	CE (*Pcm*)	0.200

Notes:

* For facilities that have no deliberate additions of Cerium, it is not necessary to report.

** The carbon equivalent shall be calculated in accordance with the requirements of Clause 9.2.4 of API 5L.

† Either the acid soluble aluminum (ASA) or total aluminum content shall be reported. It is not necessary to determine and report both values.

Restrictions:

Restriction A: See Table 9-2

Restriction B: V + Nb : 0.12 max for L360M to L485M

Restriction C: V + Nb + Ti : 0.15 max for L360M to L485M

Table 9-2: Restriction A

Carbon Content	Mn Max for L245M to L320M (BM to X46M)	Mn Max for L360M & L390M (X52M & X56M)	Mn Max for L415M & L450M (X60M & X65M)	Mn Max for L485M (X70M)	(Mn+Cr+Mo) Max for L245M to L390M (BM to X56M)	(Mn+Cr+Mo) Max for L415M to L485M (X60M to X70M)
≥ 0.09	1.30	1.40	1.50	1.60	1.85	1.95
0.08	1.35	1.45	1.55	1.65	1.90	2.00
0.07	1.40	1.50	1.60	1.70	1.95	2.02
0.06	1.45	1.55	1.65	1.75	2.00	2.07
0.05	1.50	1.60	1.70	1.85	2.05	2.20
≤ 0.04	1.55	1.65	1.75	1.90	2.10	2.25
Note: Carbon values intermediate to those listed (i.e., C=0.085) shall be rounded in accordance to ASTM E29.						

9.3 Tensile Properties

9.3.2.1 The ratio of yield strength to tensile strength (Y/T) for transverse body tensile tests, Table 7 of API 5L, shall not exceed 0.90.

9.3.2.2 The ultimate tensile strength maximum limit for the pipe body shall also apply to the weld.

9.6 Flattening Test

a) 1) For all combinations of pipe grade and specified wall thickness, there shall be no opening of the weld before the distance between the plates is less than 50% of the original outside diameter.

9.8 CVN Impact Test for PSL 2 Pipe

9.8.2 Pipe Body Tests

9.8.2.1 Pipe body tests shall meet the requirements outlined in Table 9-3 of this Specification, based upon full-size test specimens, at or lower than the pipe test temperature specified on the purchase order.

9.8.2.2 For all pipe sizes, the fracture appearance as determined by a Charpy V-notch impact test shall exhibit a fracture appearance shear area of 85% minimum for any test, with no individual test specimen exhibiting less than 75% shear area, at the test temperature outlined in the purchase order.

9.8.3 Pipe Weld and HAZ Tests

Charpy V-notch impact tests shall be conducted on test specimens taken from the weld zone. Shear area shall be reported for information only, unless otherwise specified or agreed.

Table 9-3: CVN Absorbed Energy Requirements for Pipe Body

Overall Design Factor[1]	Pipe Size in mm O.D. (NPS)	Minimum Full Size Charpy V-Notch Absorbed Energy J (ft. lbs)[6]		
		Pipe Body[2]		Weld Zone
		Any Heat[2]	All Heat Average[2,3]	Longitudinal Weld[4]
> 0.60	610 (24)	45 (33)	100 (74)	45 (33)
> 0.60	457-559 (18-22)	40 (30)	80 (59)	40 (30)
> 0.60	≤ 406.4 (16)	27 (20)	55 (41)	27 (20)
≤ 0.60	≥ 457 (18)	40 (30)	55 (41)	40 (30)
≤ 0.60	≤ 406.4 (16)	27 (20)	40 (30)	27 (20)
N/A[5]	≥ 457 (18)	40 (30)	55 (41)	40 (30)
N/A[5]	≤ 406.4 (16)	27 (20)	40 (30)	27 (20)

Notes:

[1] The overall design factor will be specified on the purchase order and the request for quote. In Canada, the overall design factor equals the design factor multiplied by the location factor.

[2] Pipe Body "Any Heat" and "All Heat Average" values are based on specific design conditions, including a maximum design pressure of 10,000 kPa (1450 psi). If the design pressure exceeds 10,000 kPa (1450 psi), the values shall be re-assessed by the Company and higher values may be specified. Higher values may also be specified for special design conditions (e.g., rich gas or lower design temperatures).

[3] The "All Heat Average" requirement is recommended, but is not mandatory, for pipe ordered for liquid hydrocarbon pipeline systems, and does not apply to pipe for orders filled by the production of less than five heats.

[4] Shear area of the weld zone shall be reported for information.

[5] N/A = Not Applicable

[6] The values in ft. lbs are converted from the values in J.

9.9 DWT Test for PSL 2 Welded Pipe

9.9.1.1 For pipe larger than 457 mm O.D. (NPS 18), the fracture appearance as determined by a drop-weight tear test shall exhibit a shear area of 85% minimum for any test, with no individual test specimen exhibiting less than 75% shear area, at or lower than the test temperature outlined on the purchase order.

9.10 Surface Conditions, Imperfections and Defects

9.10.4 Laminations

Laminations of any size extending into the face or bevel of the pipe shall be classified as defects. Pipes that contain such defects shall be rejected or cut back until no such lamination is present at the pipe ends.

9.10.5 Geometric Deviations

9.10.5.1 Geometric deviations, other than dents, from the normal cylindrical contour of the pipe (e.g., flat spots and peaks) that exceed 2.0 mm (0.08 in.) in depth or height shall be considered defects and treated in accordance with C.3 b) or C.3 c) of API 5L.

9.10.5.2.1 Dents that are 6.4 mm (0.25 in.) or less in depth and contain stress concentrators shall be considered defects and shall be cut out as cylinders and rejected, or shall be repaired by grinding to remove stress concentrators provided that the remaining wall thickness is within the specified limits.

9.10.5.2.2 Dents of any depth that intersect the longitudinal weld seam shall be considered defects and removed from the pipe as a cylinder.

9.10.6 Hard Spots

Any hard spot larger than 50 mm (2.0 in.) in any direction shall be classified as a defect if its hardness exceeds 300 HV10, based upon individual indentations.

9.10.7 Other Surface Imperfections

Other surface imperfections found by visual inspection shall be investigated, classified and treated in accordance with Clause 9.10.7 of API 5L and as follows:

a) Surface scores (sharp notches, gouges, scores, slivers, pits, etc.) and all other stress raising imperfections shall be removed by grinding even though they may be less than the maximum depth permissible for imperfections.

c) Any OD or ID imperfection having a depth that results in a remaining wall thickness at any point of less than 95% of the specified nominal wall thickness shall be considered a defect.

d) The external pipe surface shall be suitable for coating with fusion bond epoxy and polyethylene. Pipe shall have an internal surface suitable for coating with liquid epoxy. Slivers, scabs, bristles or other surface imperfections that would result in an unacceptable applied internal or external coating shall be considered defects and shall be removed by grinding.

9.10.7.1 Grinding

9.10.7.1.1 The minimum remaining wall thickness at any point after grinding shall not be less than 95% of the nominal ordered thickness.

9.11 Dimensions, Mass and Tolerances

9.11.3 Tolerances for Diameter, Wall Thickness, Length and Straightness

9.11.3.1.1 Diameter

9.11.3.1.1.1 Tolerances for diameter of the pipe, except the ends, and for diameter of the pipe ends shall be in accordance with requirements of Table 10 of API 5L, except that the diameter tolerances shall not exceed plus or minus 2.0 mm (0.08 in.) at any location along the length of the pipe.

Unless otherwise agreed, the diameter of each pipe joint shall be measured at each end (within 100 mm or 4 in.) plus three equally spaced intervals along the pipe body after hydrostatic test.

9.11.3.1.1.2 For pipe larger than 457 mm O.D. (NPS 18), the tolerances on outside diameter at the ends may be applied instead to the inside diameter at the ends.

9.11.3.1.2 Out-of-Roundness

9.11.3.1.2.1 For all pipe sizes and D/t ratios, the maximum difference between the lengths of the major and minor axes at any point along the pipe shall be in accordance with the out-of-roundness requirements of Table 10 of API 5L, with the additional requirement that in no case shall the maximum difference between the lengths of the major and minor axes at any point exceed 0.010 D.

9.11.3.2 Wall Thickness

9.11.3.2.1 The minimum wall thickness at any location shall be 95% of the specified wall thickness.

9.11.3.2.2 The average wall thickness for the quantity on the purchase order when five or more heats are provided shall not be less than the specified wall thickness. It shall be permissible to establish compliance with this requirement on the basis of mass.

9.11.3.3 Length Tolerances

a) The minimum length, minimum average length and maximum length shall be identified on the quotation by the Manufacturer and shall be subject to prior agreement by the Company.

9.11.3.4 Straightness Tolerance

b) The local deviation from a straight line in the 1,000 mm (39 in.) portion at each pipe end shall be less than or equal to 2 mm (0.08 in.).

9.12 Finish of Pipe Ends

9.12.5 Plain Ends

9.12.5.2.1 Pipe shall be furnished with a root face dimension of 1.6 mm (0.063 in.), +0.8 mm (0.031 in.), -0.0 mm (-0.0 in.) for a minimum of 95% of the circumference around each field end.

9.12.5.2.2 For station pipe orders, pipe shall be furnished with a root face dimension as per the requirements of API 5L.

9.13 Tolerances for the Weld Seam

9.13.1 Radial Offset of Strip/Plate Edges

9.13.1.1 The maximum offset for all wall thicknesses and at any location in the pipe shall be 10% of the specified wall thickness.

9.15 Weldability of PSL 2 Pipe

9.15.1 Weldability tests shall be conducted in accordance with and shall meet the requirements of the *WIC-1 Testing Procedure Specification* in Annex Q of this Specification. Weldability tests are required when the pipe is Grade L415M (X60M) or higher. Weldability tests shall not be required for station pipe orders.

9.15.2 Weldability tests shall be repeated when any of the following conditions occur:

a) the carbon equivalent, calculated in accordance with the requirements of Clause 9.2.4 of API 5L, increases by more than 0.03 from the previously accepted test result

b) the specified wall thickness increases more than 10% within one of the ranges specified in the following note:

Note:

There are two wall thickness ranges:

i. < 7.3 mm (0.288 in.), and

ii. ≥ 7.3 mm (0.288 in.)

c) the grade increases from the previously accepted test results

d) the steelmaking practice changes

e) the steel Manufacturer or the location of the steelmaking facility changes

f) when a new heat is provided, until a total of three heats have been tested and have been found to meet the requirements of Annex Q of this Specification

9.15.3 Provided that the requirements of Clause 9.15.2 of this Specification are met, successful WIC tests submitted as part of a previous order may be used to satisfy the requirements of a current order.

9.15.4 If more than one of the three test welds in a heat fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected. If one of the three test welds on any heat fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected or two additional test welds from the same heat shall be taken. If either of the two additional test welds fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected.

9.15.5 When a heat is rejected, two additional heats of steel shall be tested. If either of these additional heats is rejected, the acceptance of every heat of steel for the order shall be subject to agreement by the Company.

10 INSPECTION

10.1 Types of Inspection and Inspection Documents

10.1.3 Inspection Documents for PSL 2 Pipe

10.1.3.1 Pipe shall not be considered for acceptance until two copies of the reports and test certificates required by Clause 10.1.3 of this Specification are provided. The reports and test certificates shall be in a format approved by the Company.

10.1.3.2 In addition to the information to be provided in accordance with Clause 10.1.3.2 of API 5L, the following additional information shall be provided:

b) Chemical composition (heat and product) and acceptance criteria for all elements referenced in Table 9-1 of this Specification and all alloying elements intentionally added, carbon equivalent (heat analysis and product analysis) and acceptance criteria. Additionally, the values of all restrictions listed in Table 9-1 of this Specification shall be reported.

c) Mechanical test results, including results for body tensile tests (including Y/T ratio), transverse weld tensile tests, flattening tests, guided-bend tests, notch toughness tests and macrohardness tests, and heat number and qualification pipe number for each test. For flattening and guided-bend tests, it shall be permissible to supply certification that the tests were completed.

d) CVN impact test results, the size, orientation and location of the test pieces; the source (pipe body or weld), type (flattened or unflattened), individual and average test results for each test, type of testing machine (ISO or ASTM), heat number and qualification pipe number for each test, and acceptance criteria for each CVN test.

e) DWT test results, type of specimen (flattened or unflattened), type of notch (pressed or chevron), type of testing machine (ISO, ASTM or API), individual and average test results for each test, heat number and qualification pipe number for each test and acceptance criteria for each DWT test.

m) The results of weld zone metallographic examinations (it shall be permissible to supply a certificate that the tests were done in accordance with, and met the requirements of, this Specification in lieu of actual test results).

n) The results of all hardness tests.

o) Steelmaking method, steelmaking practice number, deoxidation practice and casting method.

p) Rolling practice number and the type of skelp rolling mill used.

q) Purchase order number.

r) Certification that non-destructive inspection was performed in accordance with, and met the requirements of Clause 10.2.10 of this Specification and API 5L.

s) A correlation of heat numbers to pipe numbers (for sequential pipe numbers), or heat numbers to pipe and coil numbers.

t) Certification that the pipe has been manufactured in accordance with the requirements of API 5L and this Specification, and/or dual certification to CSA Z245.1, if specified.

10.2 Specific Inspection

10.2.1 Inspection Frequency

10.2.1.2 The inspection frequency shall be as given in Table 18 of API 5L, and as outlined in this Specification.

4 & 6: The minimum inspection frequency for tensile testing, as per Table 18 of API 5L, shall be once per test unit of not more than 100 lengths of pipe for pipe sizes covered under this Specification.

9, 10, 11 &12: The minimum inspection frequency for CVN pipe body, weld and HAZ, Table 18 of API 5L, shall be once per test unit of not more than 100 lengths of pipe.

13: The minimum inspection frequency for DWT test for welded pipe, as per Table 18 of API 5L, shall be once per test unit of not more than 100 lengths of pipe.

14 & 15: One root guided-bend test shall be conducted for each of the leading end of the first pipe and the trailing end of the last pipe of each multiple length. For each individual slit/coil of skelp welded, a multiple length is defined to be the tubular product that is bounded by the following:

a) for slits/coils welded without an intermediate weld stop, the leading and trailing slit/coil end locations, or

b) for slits/coils welded with one or more intermediate weld stops:

i. the leading slit/coil end location and the first subsequent weld stop location

ii. any two consecutive intermediate weld stop locations, and

iii. the last intermediate weld stop location and trailing slit/coil end location

20: At least once per operating shift, and at least once for each heat of material supplied to an order, at least one metallographic examination shall be conducted on the weld area to confirm that the full weld has been heat-treated in accordance with Clause 8.8.2 of API 5L. Metallographic examination shall be conducted for all pipe orders.

10.2.3 Samples and Test Pieces for Mechanical Tests

10.2.3.1.1 Samples and test pieces for mechanical tests (tensile tests, CVN tests and DWT tests) shall be taken from the same end of the same length of pipe that is sampled for testing.

10.2.3.2 Test Pieces for Tensile Test

10.2.3.2.1 The use of round test specimens shall be subject to agreement by the Company.

10.2.3.3 Test Pieces for the CVN Impact Test

10.2.3.3.1 Test specimens for weld zone tests shall be etched prior to notching to enable proper placement of the notches. Test specimens shall be oriented transversely to the longitudinal axis of the pipe and the notches shall be located in the heat-treated area. The axis of the notch shall be located on, or as close as practicable to the weld line. Test specimens shall be full size, or the largest obtainable sub-size commensurate with the pipe geometry. The tests shall meet the requirements outlined in Table 9-3 of this Specification, at the pipe test temperature outlined on the purchase order.

10.2.4.6 **Guided-Bend Test**

10.2.4.6.1 All pipe shall be subjected to the root guided-bend test and follow Clause 10.2.4.6 of API 5L using specimens prepared in accordance with Figure 8 b) of API 5L. Specimens shall be the full wall thickness of the pipe.

10.2.4.8 **Hardness Test**

10.2.4.8.1 The results of all hardness tests shall be reported.

10.2.4.8.2 Macrohardness traverses shall be taken on a representative sample at least once per welding shift and at least once for each heat of material supplied to an order. Tests shall be conducted in accordance with the requirements of one of the following:

a) ASTM E18 and the Rockwell A, B, or C scale

b) ASTM E384, with Vickers 10 kg force load

Note:

Once a scale is selected, it shall be used for the entire order.

10.2.4.8.3 For pipe with a specified wall thickness of 5.6 mm (0.219 in.) or less, one hardness traverse along the wall thickness centerline shall be taken. For pipe with a specified wall thickness greater than 5.6 mm (0.219 in.), two hardness traverses, with one traverse near the inside surface (1-2 mm (0.040-0.080 in.)) and one traverse near the outside surface (1-2 mm (0.040-0.080 in.)) shall be taken, as shown below. Each traverse shall consist of the following:

a) one reading taken within the weld

b) one reading on each side of the weld in the heat-affected zone, and

c) one reading on each side of the weld in the parent metal

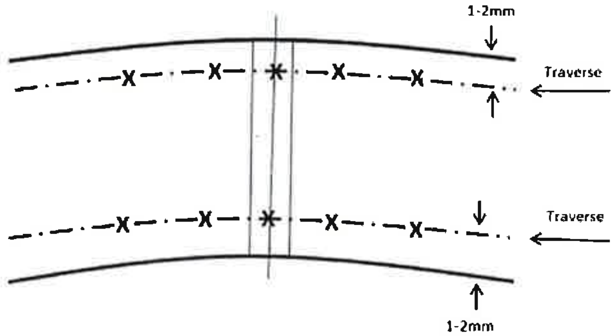


Figure 10-1: Hardness Traverse

10.2.4.8.4 Macrohardness shall not exceed 24 HRC or an equivalent value obtained by conversion from another macrohardness scale in accordance with the requirements of ASTM E140.

10.2.4.8.5 In the event of a hardness test failure, a documented proposal for the location and number of retests shall be prepared by the Manufacturer and submitted for approval by the Company.

10.2.5 Macrographic and Metallographic Tests

10.2.5.5 Weld Zone Microstructure

10.2.5.5.1 The results of all weld zone metallographic examinations shall be reported. The presence of untampered martensite shall not be allowed.

10.2.6 Hydrostatic Test

10.2.6.1 The test pressure for all pipe sizes shall be held constant for a duration of not less than 10 seconds.

10.2.6.2.1 The individual pressure recordings shall be unambiguously traceable to each pipe number and heat number.

10.2.6.2.2 Hydrostatic gauges are to be calibrated prior to commencement of production of pipe of each diameter, wall thickness and grade, at least weekly thereafter, and after all hydrostatic test failures.

10.2.6.5 The pressure of the hydrostatic test medium shall stress the pipe wall to at least 95% of the specified minimum yield strength (SMYS).

10.2.6.6 Any proposals to determine test pressure by applying end load compensation in accordance with Equation (7) of API 5L shall be indicated at the time of submission of proposals for supply. The hoop stress induced by the hydrostatic pressure as calculated by Equation (6) of API 5L (i.e., without end load compensation) shall be at least 90% SMYS.

10.2.6.7 The required test pressure shall be determined using the specified nominal wall thickness, *t*.

10.2.6.8 Reporting of Hydrostatic Test Failure

10.2.6.8.1 Each hydrostatic test failure shall be investigated and the cause of each failure determined and fully documented. The failure investigation results shall be forwarded to the Company.

10.2.7 Visual Inspection

10.2.7.1.1 The external and internal surfaces of the pipe shall be presented for final visual inspection free of oil, grease, lubricant, loose mill scale or other foreign matter.

10.2.7.1.2 All pipe shall be visually inspected. Visual inspection shall include, but not be limited to, the following:

c) the entire external surface by an inspector walking the full length of the pipe

d) the internal surface by an inspector using suitable inspection lamps

e) the pipe ends

10.2.10 Non-Destructive Inspection

10.2.10.1 All non-destructive final inspection procedures shall be submitted and accepted by the Company prior to pipe production. Non-destructive inspection shall be in accordance with Annex E of API 5L and this Specification.

10.2.12 Retesting

10.2.12.5 Guided-Bend Retests

Where one or both of the root guided-bend tests representing a multiple length fail to conform to the specified requirements, the affected multiple lengths shall be given one of the following dispositions:

a) The pipes produced from the affected multiple lengths shall be rejected.

b) The Manufacturer may elect to repeat the tests on specimens cut from two additional lengths of consecutive pipes adjacent to the defective portion from the affected multiple length. If such specimens conform to the specified requirements, all lengths in the affected multiple length shall be accepted, except the length initially selected for test. If any of the retested specimens fail to pass the specified requirements, the Manufacturer may elect to test specimens cut from individual lengths remaining in the affected multiple length. The Manufacturer may also elect to retest any length that has failed to pass the test by cropping back and cutting two additional specimens from the same end. If the requirements of the original test are met by both of these additional tests, that length shall be acceptable. No further cropping and retesting is permitted. Specimens for retest shall be taken in the same manner as the original specimen that failed to meet the requirements.

10.2.12.6 Charpy Retests

10.2.12.6.1 For CVN impact tests on pipe weld areas, failure of any test shall require two additional tests; one on the pipe immediately before the failed pipe and the second on the pipe immediately after the failed pipe. If both retests conform to the requirements, the pipe in the lot shall be accepted, except that pipe from which the initial test was taken. If one or both tests fail to meet the requirements, the Manufacturer shall take additional tests, one on the pipe welded immediately before the last retest failure, and the second on the pipe immediately after the last retest failure, until the respective tests pass the requirements. All pipe welded after the acceptable retest preceding the original failure, and all pipe welded prior to the acceptable retest after the original failure shall be rejected.

11 MARKING

11.2 Pipe Markings

11.2.1 The markings shall also include the pipe number and coil number as applicable, heat number (or code traceable to the heat number) and purchase order number.

Note:

The coil number is not required for mills that use sequential pipe numbers in lieu of coil and pipe numbers, provided that the coil number can be determined from the sequential pipe number.

11.2.3 Die-stamping and/or vibro-etching shall not be permitted on any pipe surface.

11.2.4 If agreed, the pipe markings as required on the OD of the pipe may be applied after subsequent coating application. In such case, the pipe markings on the ID of the pipe, as required per this Specification and approved for the project, shall be completed before coating application and traceability shall be ensured.

11.2.8 Additional markings applied shall be at the approval of the Company.

11.2.9 All markings required by API 5L, the purchase order number, heat number (or code traceable to the heat number), and pipe number shall be marked on the inside and/or outside surface of the pipe in accordance with Table 11-1.

Table 11-1: Location of Markings

Pipe Size in mm O.D. (NPS)	API Marking and Heat Code	Pipe / Coil Number	PO Number
≤ 355.6 (14)	OD	ID and OD	ID and OD
> 355.6 (14)	ID	ID and OD	ID and OD

The heat code, purchase order number, pipe number and, where required by Clause 11.2.1 of this Specification, the coil number shall be placed at both ends of each length of pipe.

Figure 11-1 and Table 11-2 provide further detail on where markings should be placed.

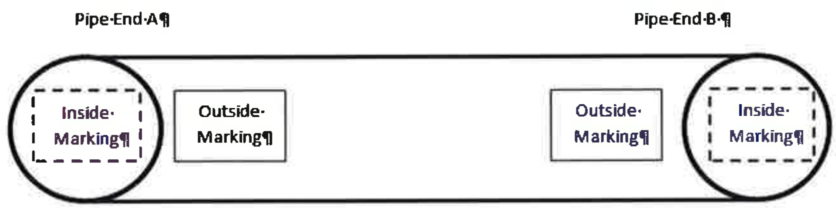


Figure 11-1: Location of Pipe Markings

Table 11-2: Specific Location of Pipe Markings

Pipe Size in mm O.D. (NPS)	Pipe End A		Pipe End B	
	Outside Marking	Inside Marking	Outside Marking	Inside Marking
≤ 355.6 (14)	1. API 5L Clause 11 requirements 2. Pipe Number 3. PO Number	1. Pipe Number 2. PO Number	1. Pipe Number 2. PO Number	1. Heat Code 2. Pipe Number 3. PO Number
> 355.6 (14)	1. Pipe Number 2. PO Number	1. API 5L Clause 11 requirements 2. Pipe Number 3. PO Number		

12 COATINGS AND THREAD PROTECTORS

12.1 Coatings and Linings

12.1.1 Unless otherwise stated on the purchase order, pipe shall be supplied with bare metal finish.

15 ADDITIONAL DOCUMENTATION REQUIREMENTS

15.1 Documentation Requirements

15.1.1 The Manufacturer shall submit the following documents to the Company within the time period shown:

a) Weldability test results no later than the cargo shipment readiness date (see Clause 9.15 of this Specification).

b) Number of metres shipped and number of pipe lengths shipped within five working days after each shipment.

c) For orders of 10 heats or more, product histograms for each of the items listed in Table 15-1 shall be supplied within one month after the completion of production. The minimum, maximum, arithmetic mean (average), median value, number of samples and standard deviation shall be reported clearly either in the histograms or separately. For items 1 to 15 in Table 15-1, histograms shall be prepared for both the heat analysis and product analysis.

Table 15-1: Items Requiring Product Histogram Documentation

1. Carbon Equivalent	13. Titanium
2. Carbon	14. Aluminum
3. Manganese	15. Nitrogen
4. Silicon	16. Transverse Yield strength
5. Sulfur	17. Transverse Tensile strength
6. Phosphorus	18. Transverse Weld Tensile Strength
7. Copper	19. Yield/Tensile ratio (Y/T)
8. Nickel	20. CVN Absorbed Energy - pipe body
9. Chromium	21. CVN Shear Area - pipe body
10. Molybdenum	22. DWTT Shear Area - pipe body
11. Vanadium	23. CVN Absorbed Energy – weld
12. Niobium (Columbian)	24. CVN Shear Area – weld

d) In addition to the reports and test certificates supplied with the pipe shipments, the final certification documents shall be submitted within two weeks of completion of production. Two paper copies and one non-modifiable searchable electronic copy are required.

15.2 Pre-Production Documentation Requirements

15.2.1 The Manufacturer shall supply the Company, at the time of quotation, any exceptions or alternatives to this Specification. The minimum length, minimum average length and maximum length shall be identified at the time of quotation. In addition, the centerline segregation acceptance level shall be presented.

15.2.2 The Manufacturer shall supply the Company, at the time of quotation, a Manufacturing Procedure Specification (MPS) (see Clause 8.14 of this Specification).

15.2.3 Prior to the commencement of production, the Manufacturer shall submit or have previously submitted to the Company the following documents, and shall have received written acceptance of such from the Company:

a) Ultrasonic inspection procedures for the skelp or pipe body (see Clause 8.3.2.3 of this Specification).

b) Ultrasonic inspection procedure for the weld (see Clause E.5.8 of this Specification).

c) If applicable, an alternative procedure for removing markings identifying imperfections (see Clause E.3.5.1 of this Specification).

d) Liquid penetrant, magnetic particle or ultrasonic inspection procedures, whichever are applicable, for the pipe ends (see Clause E.3.4.1 of this Specification).

e) Procedures for the welding of electric welded pipe. These procedures shall include production limits for such items as travel speed, welder electrical frequency, power input into weld and heat-treating temperature used in making the weld.

The Manufacturer shall inform the Company in writing of any changes to the above documents and shall obtain the written acceptance of the Company for such changes prior to implementing the changes.

15.2.4 The Manufacturer shall have written procedures for the loading, shipping and storage of pipe. These procedures are to be made available to the Company on request.

16 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are listed in Table 16-1, Table 16-2 and Table 16-3. Use the latest document revision, unless otherwise approved by TransCanada.

Table 16-1: Regulatory References

Organization/Document No.	Title
National Energy Board (NEB)	SOR/99-294, *National Energy Board Onshore Pipeline Regulations (NEB OPR)*
NOM-007-SECRE	*Transporte de Gas Natural*
U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) Code of Federal Regulations (CFR)	Title 49 Part 192, *Transportation of Natural Gas by Pipeline: Minimum Safety Standards*
	Title 49 Part 195, *Transportation of Hazardous Liquids by Pipeline*
Various	Other applicable federal, provincial and territorial safety acts and regulations by the authority having jurisdiction

Table 16-2: External Industry References

Organization/Document No.	Title
American Petroleum Institute (API)	5L, *Specification for Line Pipe*
American Society for Testing and Material (ASTM)	E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*
	E140, *Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness*
American Society of Mechanical Engineers (ASME)	B31.4, *Pipeline Transportation Systems for Liquids and Slurries*
	B31.8, *Gas Transmission and Distribution Piping Systems*
	BPVC-IX, *Welding and Brazing Qualifications*
Canadian Standards Association (CSA)	Z245.1, *Steel Pipe*
	Z662, *Oil and Gas Pipeline Systems*

Table 16-3: Internal References

Document No.	Title
For this Specification, there are no specific Internal references.	

17 DOCUMENT HISTORY

Rev.		
05	**Description**	**Effective Date**
	Revised document developed as part of Columbia Pipeline Integration.	2017-Aug-01
	Rationale Statement	**Responsible Engineer**
	This document was revised to address the following requirements: • Integration of Columbia Pipeline requirements.	Jessica de Vries, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group, to integrate Columbia Pipeline requirements, and to make it more easily accessible to those who use it	Jessica de Vries, P. Eng.
04	**Description**	**Effective Date**
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	**Responsible Engineer**
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Jessica de Vries, P. Eng
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group and to make it accessible to those who use it.	Jessica de Vries, P. Eng

18 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
N/A	This Specification was updated and put into the new template. Changed name from TES-PIPE-EW to TES-MA-EWPI-GL following new naming convention.

19 APPROVALS

APPROVALS		
Originator: Derek Chen, P. Eng. Materials and Welding Engineering	Signature	June 26, 2017 Date
Reviewer: Cindy Guan, P. Eng. Materials and Welding Engineering	Signature	June 26 2017 Date
Reviewer: Jaclyn Brown, P.E. USGO Integrity Program Services	Signature	6/27/2017 Date
Responsible Engineer: Jessica de Vries, P. Eng. Materials and Welding Engineering	Signature June 26, 2017 Date	June 26, 2017 APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, P. Eng., Manager Materials and Welding Engineering	Signature	June 26, 2017 Date

ANNEX B MANUFACTURING PROCEDURE QUALIFICATION FOR PSL2 PIPE

B.3.1 Manufacturing Procedure Specification (MPS) Requirements

The Manufacturing Procedure Specification (MPS) submitted shall include, at a minimum, the following detailed information:

a) steel source, including steelmaking method, heat size, deoxidation practice, inclusion shape control practices and casting method

b) aim chemistries and chemical limits for all elements referenced in Clause 9.2 of this Specification, and as applicable to pipe of each diameter, wall thickness and material grade to be made for the order

c) skelp rolling source, specific rolling and forming practices, including where applicable, typical reduction schedules, final finishing temperatures, coiling temperatures or accelerated cooling stop temperature, and facilities for thermo-mechanical controlled rolling and on-line accelerated cooling

d) skelp inspection procedures as applicable

e) details of pipe forming procedures

f) pipe manufacturing location, and any plant limitations on wall thickness, diameter and material grade

g) welding method (induction or contact method), typical electrical parameters (voltage, amperage, and frequency) and production limits on travel speed, power input and post-weld heat treating temperature applicable to pipe for the order

h) a description of the quality organization applicable to steelmaking, casting, skelp rolling and pipe manufacturing facilities, including identification of reporting practices, verification mechanisms to assure product traceability in accordance with the requirements of API 5L, and responsibility for customer contact related to commercial and quality matters

i) a flow chart for pipe manufacturing, finishing and qualification processes

j) normal mill control tolerances, assessment and recording frequencies for all specification dimensions for pipe

k) laboratory test equipment present at the manufacturing plant for testing of material properties for the order

l) all non-destructive inspection procedures utilized for specification compliance and for production control, as applicable to skelp, pipe body and welds

m) method and typical amount of cold sizing/expansion, as applicable

n) yard handling, storage and shipping procedures, including drawings of proposed methods of stacking and securing pipe for shipment and method of end protection

o) order-specific Inspection and Test Plan (ITP) for Company review and approval

ANNEX E NON-DESTRUCTIVE INSPECTION FOR OTHER THAN SOUR SERVICE OR OFFSHORE SERVICE

E.1 Qualification of Personnel

E.1.1 ISO 9712 shall be the basis for the qualification of non-destructive inspection personnel (excluding visual inspection). Such personnel shall be re-qualified for any method previously qualified if they have not performed non-destructive inspection in that method for a period exceeding 12 months.

E.1.2 Non-destructive inspection shall be conducted by Level 2 or 3 personnel.

E.1.3 Evaluation of indications shall be performed by Level 2 or 3 personnel.

E.3 Methods of Inspection

E.3.1.3 The location of equipment in the Manufacturer's facility shall be such that all non-destructive inspection for compliance to specification requirements shall be performed after final hydrostatic testing.

E.3.4 Pipe End Bevel Inspection

E.3.4.1 The bevel area of all pipe shall be inspected for laminations by an ultrasonic inspection technique. Alternatively, the root face and bevel shall be inspected for laminations by a liquid penetrant or a magnetic particle technique after beveling. The inspection procedure shall be documented and accepted by the Company prior to production.

E.3.5 Removal of Markings

E.3.5.1 Any paint markings applied to the pipe to mark locations where alarm limits were exceeded or where imperfections were noted shall be removed or painted over with black paint, after it has been confirmed that a defect is not present. The Manufacturer may submit an alternative procedure for acceptance by the Company in writing if this requirement deviates from their standard practice.

E.5 Ultrasonic and Electromagnetic Inspection

E.5.1 Equipment

E.5.1.2 Search Units

E.5.1.2.1 The angle of the search units shall be selected to provide as near to perpendicular incidence of the soundbeam axis to the weld fusion line as is practical.

E.5.1.3 **Couplant**

E.5.1.3.1 An audio device shall be used to indicate the loss of coupling effectiveness.

E.5.2 Ultrasonic and electromagnetic inspection reference standards

E.5.2.3.1 Reference standards for standardization and inspection sensitivity checks shall contain machined standardization reflectors as follows:

a) 3.2 mm (0.125 in.) radially drilled hole for calibration and for application of acceptance limits and for setting of alarm levels.

b) For piping to be used in above ground assembly or station piping, a 1.0 mm (0.039 in.) radially drilled hole shall be used for calibration and for application of acceptance limits and for setting of alarm levels.

c) Notches, longitudinal orientation, depth 5% of specified wall thickness, dimensional tolerances as specified in Table E.7 of Annex E of API 5L, for the verification that the sound beam for longitudinal defect inspection is being directed perpendicular to the weld line.

E.5.3 Instrument standardization

E.5.3.1.1 Any signal suppression and electronic dampening implemented for standardization shall be identical to that implemented for inspection of the pipe during production.

E.5.3.1.2 Standardization shall be performed at the start of production, after the inspection sensitivity checks required by Clause E.5.4.1.1 of this Specification, and at the start of inspection after any shutdown of the ultrasonic inspection equipment during production. The inspection equipment shall be adjusted to obtain, from the applicable reference standards used to establish the acceptance limits, signals that are within the gate width and exceed the alarm limit, when the reference standard is scanned in a manner duplicating inspection in the dynamic mode.

E.5.3.1.3 The gate start locations and gate widths shall be validated during calibration by positioning the search units at locations coincident with the extremes of the tracking error, and producing signal amplitude at or above the alarm limit signal produced from the standardization reflector.

E.5.4 Records verifying system capability

E.5.4.1.1 The inspection sensitivity shall be checked at least twice every working shift, prior to any planned shutdown of the ultrasonic equipment during production, and at the end of production, using the reference standard containing the machined calibration reflectors specified in Clause E.5.2.3.1 of this Specification. For inspection sensitivity checks, the reference standard shall be run through the ultrasonic equipment at production speed.

E.5.4.1.2 Where the signal obtained from the standardization reflector is more than 3dB lower than the acceptance limit, all pipe inspected after the preceding acceptable standardization shall be re-inspected after re-standardization has been accomplished.

E.5.5 Acceptance Limits

E5.5.1.1 For inspection of the pipe welds, any imperfection that produces a signal greater than the applicable acceptance limit signal for the applicable radially drilled hole or transverse notch shall be considered to be a defect, and shall be dispositioned in accordance with Clause C.4 of Annex C of API 5L.

E.5.8 Procedures

An ultrasonic procedure shall be submitted to the Company for review and written acceptance prior to the start of production. The procedure shall include, but not be limited to, the following information as applicable to both the production-speed inspection system, and to any system used for manual prove-up of noted imperfections:

a) ultrasonic instrument equipment manufacturer(s) and model number(s)

b) industry recognized standard for verification of linearity as performed on instrumentation

c) a drawing clearly outlining the number of ultrasonic transducers in the system, and the location and position of all of the transducers

d) a drawing clearly outlining the identified area of inspection for each transducer, which clearly shows the gate width setting for each transducer or transducer set for dynamic mode inspection

e) a drawing or statement clearly outlining the maximum tracking error

f) a drawing clearly outlining the design of the reference standard, with details of the location and orientation of holes and surface notches used for standardization

g) the alarm limit settings applied for each of the applicable transducers or transducer sets

h) the mode of operation of each transducer or pair of transducers (pulse echo, transmit only, or receive only)

i) coupling medium utilized for the system

j) coupling alarm method

k) the shape and dimensions of each transducer

l) nominal search unit frequency for each transducer

m) sound entrance angle for each transmitting transducer

n) pulse repetition rate for each transducer or transducer set

o) maximum production-speed of pipe through the system

p) the marking device utilized and if applicable, the marking method and location of marking on the pipe as related to imperfection location

q) standardization procedure, including frequency for standardizations

r) sensitivity check procedure, including frequency for sensitivity checks

E.7.6 Four readings shall be taken approximately 90° apart around the circumference of each end of the pipe. The average of the four readings shall be ≤ 2.5 mT (25 Gauss), and no one reading shall exceed 3.0 mT (30 Gauss) when measured with a Hall-effect gaussmeter or equivalent values when measured with another type of instrument.

ANNEX Q WIC – 1 – TESTING PROCEDURE SPECIFICATION

Q1.0 SCOPE

Q1.1 This Specification defines the procedures and acceptance criteria for the evaluation of the weldability of line pipe material using the modified WIC test. The modified WIC test is a single pass restrained groove weld produced with cellulosic electrodes and it is used to evaluate the material's susceptibility to hydrogen cracking.

Q1.2 This Specification is applicable to the qualification of carbon and low-alloy steel pipe material.

Q2.0 TESTING PROCEDURE

Q2.1 Test assemblies

The materials required to fabricate the test assembly shown in Figure Q-1 are listed in Table Q-1. Each assembly shall be fabricated as follows:

The stiffener plate shall be welded to the bottom of the backing plate to prevent joint rotation. The shims shall be located beneath the test sections (Figure Q-2) and the test sections shall be fillet welded to the backing bar with a root gap of 1.5 mm ± 0.5 mm (typical). The restraint fillet welds shall be made using a low hydrogen process and welding shall proceed outwards relative to the weld joint preparation, see Figure Q-3. A distance of 25 mm ± 0.5 mm, centered over the weld joint preparation, shall not be welded to the backing bar and this constitutes the restraint length. Run-on and run-off tabs shall be used to ensure uniform weld deposition within the test weld. The run-on and run-off tabs shall be tack-welded to the backing plate only.

Q2.2 Number of test welds and preheat

For each heat of steel, a minimum of three acceptable test welds shall be evaluated to determine the cracking percentage at the preheat temperature given in Table Q-2.

Q2.3 Welding technique

Q2.3.1 All welding shall be performed in the vertical down direction with the test assembly located vertically (ASME Section IX 3G position). Welding can be performed manually; however, extensive practice may be required to achieve uniform travel speeds.

Q2.3.2 Test assemblies shall be uniformly heated in an oven to a temperature slightly higher than the desired preheat temperature. The assembly shall be removed from the oven and the temperature at the bevels monitored using a contact thermocouple. Welding shall begin as the required preheat given in Table Q-2 is reached.

Q2.3.3 Welding shall be performed with the consumables given in Table Q-2.

Q2.3.4 Welding parameters shall be monitored using external instrumentation for all tests. The combination of welding parameters shall be such that the resulting heat input is within the range given in Table Q-2.

Q2.4 Acceptable test weld workmanship

Q2.4.1 WIC test welds shall have a profile that is typical of the cellulosic root bead used for pipeline welding (see Figure Q-4). The weld shall be free of significant geometric flaws, which includes the following workmanship discontinuities:

a) incomplete penetration of the root bead

b) incomplete fusion of the root bead

c) porosity and hollow bead

d) coupon misalignment (high-low)

e) weld metal centre line solidification cracks

Q2.4.2 The test weld will be sectioned in accordance with the requirements of Clause Q2.5. The minimum weld throat thickness for each section shall be as given in Table Q-2. Unless the section is free of cracks, variation in the WIC test weld throat thickness for each section shall not exceed twice the actual throat thickness (depth of weld h_w, Figure Q-4). Should any of the examined sections fail to meet the workmanship requirements, the entire weld shall be discarded and replaced with another WIC test weld that meets the workmanship requirements.

Q2.5 Measurement of total crack percentage

The test welds shall be allowed to cool to room temperature and removed from the backing bar 24 hours after welding. If complete cracking occurs through the test weld, the total cracking percentage is 100%. If complete cracking through the weld does not occur, the weld shall be sectioned and examined microscopically for cracking. The weld shall be sectioned at the 1/4, 1/2 and 3/4 positions as shown in Figure Q-4. Faces 1A, 2A, 2B and 3B shall be polished, etched and examined at a magnification of 100X. The depth of cracking, h_c, and the depth of the weld (actual throat thickness), h_w, shall be determined for each section and the total cracking percentage for each test weld reported as follows:

$$\frac{\sum h_c}{\sum h_w} \times 100$$

Q3.0 ACCEPTANCE CRITERIA

Q3.1 Total cracking percentage

No single test weld shall result in a total cracking percentage exceeding the value given in Table Q-2.

Q4.0 REPORTING

A final report shall be completed for each weldability evaluation. The report, to include all the test welds completed for the evaluation, shall contain the following information:

a) material description

b) diameter, wall thickness and grade of the pipe tested

c) heat number

d) steelmaking practice (as identified by a unique practice number), steel manufacturer, and location of steel mill

e) mill test chemistry

f) consumable brand name, consumable manufacturer's traceability number (heat number, batch number or both), and the electrode diameter

g) weld parameters (amps, volts, travel speed and heat input) and preheat

h) crack dimensions and bead dimensions

i) summary of test results

j) test personnel names

k) date and number of report

l) signed certification

Table Q-1: Test Assembly Material Dimensions

Quantity	Material	Dimensions			Comments
		Thickness, t (mm)	Width, w (mm)	Length, l (mm)	
2	Test sections, (material under evaluation)	Thickness to be tested	50±1	150±5	One end prepared with standard bevel of pipe specification and oriented such that the actual test weld is deposited perpendicular to the plate/coil rolling direction or to the longitudinal axis of the pipe.
1	Backing plate, mild steel	19 min.	75 min.	300 min.	
1	Stiffener plate, mild steel	19 min.	75 min.	300 min.	
2	Backing shims, steel	3 min.	50 + 1, -10	140 +1, -20	

Quantity	Material	Dimensions			Comments
		Thickness, t (mm)	Width, w (mm)	Length, l (mm)	
2	Run on/off tabs, steel	3 min.	19±5	25 min.	Same thickness as backing shim.

Table Q-2: Testing Requirements

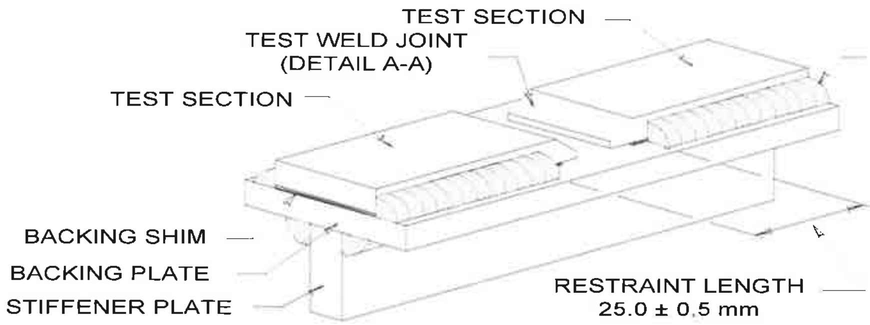
Testing Requirements[2]	Test Sample Nominal Thickness (mm)	
	< 7.3	≥ 7.3
Preheat Temperature (°C)	60±1	75±1
Electrode Classification	E55010-G (E8010-P1)[1]	E55010-G (E8010-P1)[1]
Electrode Diameter (mm)	3.2	4.0
Heat Input (kJ/mm)	0.55 - 0.65	0.65 - 0.75
Typical Welding Parameters	100 - 125 A 23 - 25 V 300 mm/min.	130 - 140 A 22 - 24 V 300 mm/min.
Minimum Weld Throat Thickness of each Section (mm)	2.0	2.5
Maximum Allowable Total Cracking Percentage (%)	5	3

Notes:

[1] Approved electrodes: Phoenix Cel-80, Lincoln 70+, Bohler Fox Cel 85

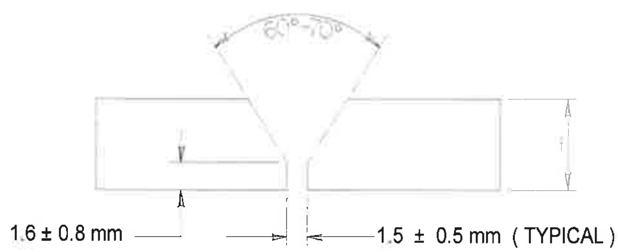
[2] The same supplier and consumable manufacturer's traceability number (heat number, batch number or both) shall be used for a series of tests.

CAUTION: Discretion is advised to the Manufacturer and/or test lab that the use of aged electrodes may affect test results.



NOTE:

1. SEE TABLE 1 FOR DIMENSIONS NOT SHOWN.
2. RUN ON/OFF TABS (NOT SHOWN) SHALL BE TACK WELDED TO BACKING PLATE ONLY.
3. BACKING SHIMS ARE PLACED BETWEEN TEST PLATES AND BACKING PLATES.



Test Weld Joint - Detail A-A

Figure Q-1: Modified WIC Test Assembly

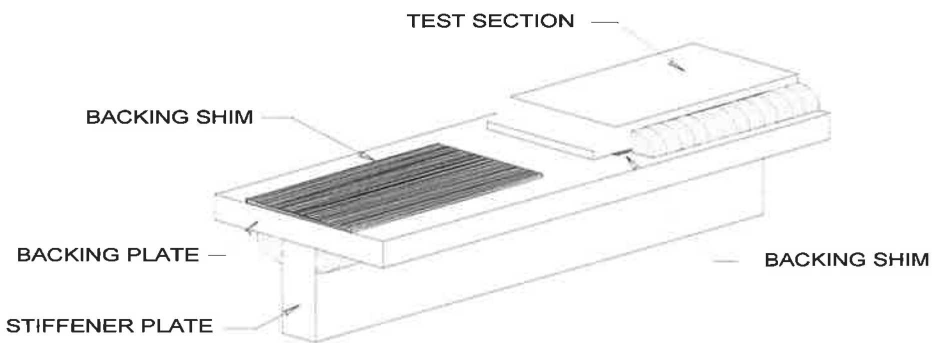


Figure Q-2: Backing Shim Location

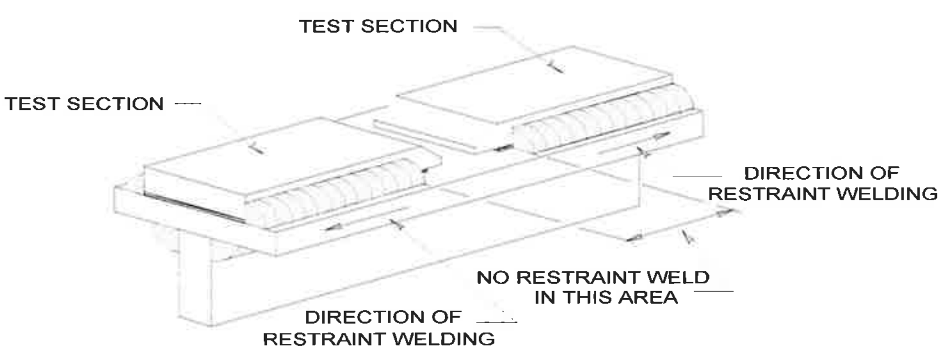
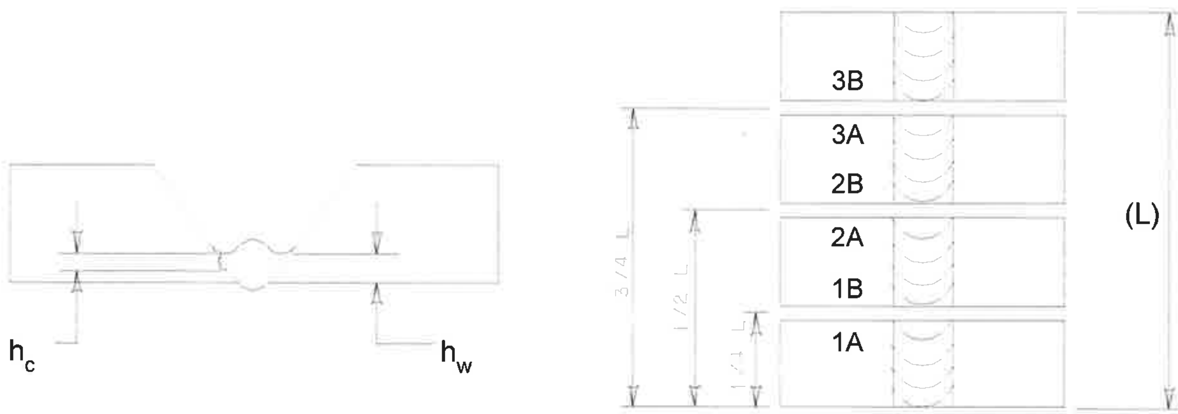


Figure Q-3: Test Section and Restraint Weld Location



NOTE:

1. TEST WELD BEAD SHALL EXHIBIT COMPLETE ROOT PENETRATION AND FUSION.
2. IF h_w IS DIFFERENT ON THE 2 SIDES OF THE WELD USE THE MINIMUM VALUE.
3. (L) - TEST WELD LENGTH
4. h_w - DEPTH OF WELD
5. h_c - DEPTH OF CRACKING

Figure Q-4: Weld Specimen Sectioning

PURPOSE

The purpose of this Specification is to identify the requirements for tightening flange bolts and is intended to be used by those performing the installation of a flanged joint.

SCOPE / APPLICABILITY

This Specification applies to tightening of new and existing flange bolts in all TransCanada facilities such as:

- pumping stations
- compressor stations
- meter stations
- pipelines
- power facilities

This Specification also applies to piping with the following characteristics:

- diameter NPS 1/2 to NPS 48
- pressure classes ANSI 150 (PN20), 300(PN50), 600(PN100), 900(PN150), 1500 (PN250) and 2500 (PN420)
- operating temperatures up to and including 120°C (248°F)
- ASME B16.5 flanges
- ASME B16.47 flanges
- CSA Z245.12 flanges

Requirements for joint tightening of flanges that are not ASME B16.5, ASME B16.47 or CSA Z245.1 flanges shall be determined by the Company Mechanical Engineer.

This Specification does not apply to (consult the Company Mechanical Engineer if encountered):

- pressurized joints/flanges (hot torqueing)
- flat face flanges
- valve bonnets (control valve, gate valve or check valve)
- rotating equipment suction and discharge flanges
- equipment anchor bolting
- structural flanges
- special applications (e.g., for orifice meters, refer to manufacturer's specification)

- use of Superbolt/Supernuts

Within this Specification, TransCanada is referred to as the Company.

Within this Specification, the following terms and definitions apply for requirements:

- Shall—expresses a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard. Shall is not a recommendation but a requirement. A variance may be requested but is unlikely to be granted.
- Should—expresses a strong preference, recommendation or that which is advised, but not required.
- Must—denotes a requirement of the Company, for which no deviation or variance would be granted.
- May—expresses an option or that which is permissible within the limits of the standard.
- Consider—assumes that a competent person will evaluate options to fulfill the intent of the requirement and make a documented decision supported by evidence to ensure protection of people, equipment and the environment by achieving the appropriate level of functional integrity.

Wherein the Manufacturer's literature, governmental or regulatory requirements conflict with this Specification, the more stringent requirement shall govern.

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1 GLOSSARY

ASME

American Society of Mechanical Engineers

Coefficient of Friction (f)

The ratio of the force of friction between two bodies and the force pressing them together.

CSA

Canadian Standards Association

Hammer Wrench

A wrench designed to be struck by a hammer on the anvil area in order to loosen frozen fasteners or to set and tighten fasteners. Also known as a striking wrench.

Hydraulic Tensioner

A machine that utilizes hydraulic pressure to put longitudinal tension (stretch) onto studs. While the pressure is applied at the value indicated on the accompanying chart, the stud nuts are hand tightened against the flanges. When the pressure is released, the tension remaining on the stud is equivalent to the pressure that would have been created by rotating the nut to the pre-determined torque value.

Hydraulic Torque Wrench

A machine that utilizes hydraulic pressure to rotate the nuts on studs or bolts. The pressure shown on the gauge can be converted to a torque value by utilizing the chart that accompanies the machine.

Insulating Gasket

A gasket that isolates two mating flanges to reduce the likelihood of creating a galvanic cell which would result in corrosion of the flanges and piping. It is one part of an Insulation Set. See also Insulation Set.

Insulation Set

Insulating materials that reduce the likelihood of galvanic corrosion between flanges and prevent the flow of electrostatic charge to reduce sparking in hazardous environments. The set is comprised of an insulation gasket and each bolt is insulated with a pair of insulating sleeves, a fibre and a metal washer. See also Insulating Gasket.

Pneumatic Torque Wrench

A torque wrench machine that uses pneumatic pressure. See also Hydraulic Torque Wrench.

Raised Face (RF) Flange

A flange on which the gasket surface is raised above the bolting circle face. This face type allows for a wide variety of gasket designs to be installed. The purpose of the raised face flange is to concentrate more pressure on a smaller gasket area and thereby increase the pressure containment capability of the joint.

Ring Type Joint (RTJ) Flange

A flange typically used in high pressure (Class 600 and higher ratings) and/or high temperature services (above 427°C/800°F). The RTJ flange has a groove cut into the face which holds steel ring gaskets. Tightening the bolts allows the flanges to seal by compressing the gaskets between the flanges into the grooves. The gasket material is deformed thus making intimate contact inside the grooves, creating a metal-to-metal seal. A RTJ flange may have a raised face with a ring groove machined into it, though this raised face does not serve as part of the sealing mechanism.

SAE

Society of Automotive Engineers

2 GLOBAL REQUIREMENTS

2.1 General Requirements

2.1.1 All materials shall conform to the following Company material specifications:

- *TES-MATL-MD1 Piping System Materials for Pipeline, Compression and Metering Facilities (*EDMS No. 3764909)
- *TES-MATL-MD1-L Piping System Materials for Pipeline, Pump, Metering and Terminal Facilities (CDN-US-MEX) (EDMS No.* 7935312*)*
- *TES-MATL-MD1-US Piping System Materials for Pipeline, Compression and Metering Facilities (CDN-US-MEX) (*EDMS No. 4471280*)*
- *TES-MATL-MD2-US Piping System Materials for Pipeline, Compression and Metering Facilities Design to -20°F (US-MEX) (EDMS No. 7073999)*

2.2 Pre-Job Planning Requirements

2.2.1 The flange tightening activity shall be discussed prior to assembly. The involved workers shall review appropriate drawings to identify the flanges that need to be installed or maintained.

2.2.2 All flange tightening personnel shall be qualified.

2.2.2.1 For US installations, personnel must be qualified as per relevant company operator qualification.

2.2.3 Flange tightening personnel shall be accountable for ensuring the safety and quality of the flange assembly/tightening work.

2.2.4 The *Flange Installation Quality Control Form* (EDMS No. 7279729) shall be completed for each flange assembled, NPS 12 and above, reviewed by the Company Inspector and provided in the turnover package.

2.2.5 For projects, with multiple flange assemblies of NPS 12 or greater, it is recommended a Flange Torque Map be created. If a Flange Torque Map is created, each flange shall be assigned a unique number, the unique number shall be indicated on the Flange Installation Quality Control Form (EDMS No. 7279729) and be relayed onto a table, sketch or isometric indicating the location of the flange assembly ensuring traceablity.

2.2.6 The following shall be verified prior to flange bolting:

- flange size
- flange pressure class/rating
- flange configuration
- number of studs and stud grade

- stud diameter and stud lengths (flanges being tightened with a hydraulic tensioner require extra-long studs as identified in Appendix C, Appendix D, Appendix E and Appendix F)
- nut size and grade
- appropriate tightening method is selected (manual or hydraulic torque wrench, hydraulic tensioning)
- torque values specific to the type of studs and lubrication used
- adequate lubrication (see section 3.7)
- type of gasket to be used
- hardened steel washers required (and supplied) with insulation kits
- SAE through hardened through washers may be considered for pitted or damaged flanges

3 REQUIREMENTS FOR RAISED FACE AND RTJ FLANGES

Unless otherwise noted, the flange bolting personnel performing the joint installation shall perform the following activities.

3.1 General Requirements

3.1.1 Inspect flange faces for damage (e.g., dents, scratches, dirt, contaminants, other deleterious material, etc.).

3.1.2 If damage is observed, contact the Company Mechanical Design Engineer or Materials Engineering prior to proceeding with flange usage. See ASME PCC-2 for flange repair if required.

3.1.3 Align flange to ensure adequate clamping stress for seating the gasket and prevent damage to the gasket during installation. Ensure flange faces are lined up in all directions (axial with the pipe, planar, and torsional) to eliminate stress in the flange joint. Ensure flange joint alignment is in accordance with Appendix H and ASME-PCC-1.

3.1.4 Ensure a metal-to-metal contact of Ring Type Joint (RTJ) flange groove and gasket ring for proper sealing.

3.1.5 Preferred practice is to use washers on both sides of the flange joint for each bolt-up.

3.1.6 For flanges requiring insulating gasket sets, use sleeves, fiber washers and metal washer to insulate one flange from the other.

3.1.7 For installations where unique conditions such as high temperature or high vibration may exist, re-torqueing may be required. Consult with the Company Mechanical / Stress Engineer.

3.2 Gaskets

3.2.1 Use only new gaskets of the correct type, material and size for the application. *Do not install a previously used gasket.*

3.2.2 Refer to the *TES-CP-MS (CDN-US) Cathodic Protection Materials Specification* (EDMS No. 3670944) for acceptable insulating gaskets.

3.2.3 Check new gaskets for damage and discard if damaged.

3.2.4 Do not lubricate gaskets as this will prevent proper sealing.

3.2.5 Handle gaskets containing asbestos using appropriate safety procedures and personal protective equipment. Refer to the *Asbestos Management Procedures Canada and Mexico (EDMS No.* 3671361*)* and *Asbestos Management Procedures U.S. (EDMS No.* 3864096*)* for more information on working with gaskets that contain asbestos.

3.2.6 Do not use power tools (e.g., grinders) to remove asbestos gaskets.

3.2.7 Use specialized cleaning methods for cleaning the flange face.

3.2.8 Refer to the below tables for gasket applications and type examples. All gasket materials shall conform to the Company's material specifications in accordance with section 2.1.1.

Table 3-1: Raised Face Gaskets for Class 150-2500

Application	Type / Material	Trade Names
Regular Flange Sealing	Spiral Wound w/ Inner and Outer Carbon Steel Ring + non-asbestos winding	Flexitallic Style CGI Garlock RWI (Class 600 or less)
	Compressed Fiber	Garlock HT 9850 (Class 600 or less)
Insulation Kit	Flat Ring (Type F) / Fiber Reinforced Epoxy	See section 9.1.1 of TES-CP-MS Corrosion Prevention Material Specification (EDMS No. 003670944)

Table 3-2: Ring Type Joint Gaskets for Class 600-2500

Application	Type / Material	Trade Names
Ring Joint Flange Sealing	Soft, Solid Metal Ring-Type Joint Gasket	
Insulating Kit	Ring-Type (Type F) / PTFE	GPT VCS

3.2.9 Ring gaskets are available in oval or octagonal configurations. Octagonal configurations should not be used on older flanges that have a rounded profile at the bottom of the gasket groove. For such cases, an oval configuration should be used to ensure proper joint contact. The oval configuration fits all ring joints whereas the octagonal configuration fits only new ring joints. The octagonal design is considered more reliable and should be used for all new ring joints.

3.3 Studs/Bolts

3.3.1 Studs may be re-used provided the threads show no damage or elongation, are free of debris, paint and rust, and a new nut is able to turn the entire length of the stud by hand. Discard any studs and bolts that do not satisfy all of these requirements.

3.3.2 Where common grade fasteners are used (e.g., ASTM A320 Gr7 studs and ASTM A194 Gr4 or Gr7 nuts), new bolts and nuts should be used for diameters of 1-1/8 in. and smaller.

3.3.3 Teflon coated studs may be re-used provided they are lubricated in accordance with section 3.7 and torqued in accordance with lubricated target torque values found in the appendix. Do not use Teflon target torque values on re-used Teflon coated studs.

3.3.4 Ensure studs/bolts used at coastal facilities and pipelines are coated with either Xylan, Teflon, or as specified by the project.

3.3.5 At coastal facilities and pipelines, use new bolts with each installation.

3.4 Nuts

3.4.1 Nuts may be re-used provided threads are not damaged and all dirt and debris is removed from the nut threads. Verify threads are not damaged by ensuring they run freely onto the stud. Discard any nuts that are damaged.

3.4.2 Lubricate between face of nut and flange, see section 3.7 for lubrication details.

3.5 Washers

3.5.1 If steel washers are to be installed, lubricate between the face of the nut and the washer on the side of the flange torque is being applied.

3.5.2 Use fully hardened SAE steel washers. Do not use surface hardened steel.

3.6 Requirements when Using Torque/Tensioning Equipment

3.6.1 When using torque equipment, ensure stud bolts installed in the flange joint extend a minimum of one to three threads past the nut on each side of the flange.

3.6.2 When using bolt tensioning equipment, ensure the stud on the working side of the flange extends 1.5 times the diameter of the stud bolt past the nut. This allows proper thread engagement onto the bolt tensioner (e.g., 2 in. stud bolt would have 3 in. thread extending past the nut face).

3.7 Lubrication

3.7.1 Appropriate lubrication must be used on all studs not coated with Teflon or Xylan.

3.7.2 Selected lubricants shall achieve a coefficient of friction ≤ 0.11 or a nut factor (K) ≤0.15. Examples of such lubricants which meet Mil-Spec 907A include:

- molybdenum-disulfide grease
- Bostik Never-Seez
- Fastorq 70+

- Jet-Lube MP-50
- Sweeney 503
- Loctite Moly Paste

3.7.3 Teflon or Xylan coated studs do not require lubricant and have a coefficient of friction of approximately 0.055 and 0.04 respectively for an estimated nut factor of K = 0.10. See section 3.3 for re-use of Teflon or Xylan coated stud bolts.

3.8 Disassembly of Flanged Joints

3.8.1 Confirm that the line is depressurized and bled off of any gas or oil before starting disassembly on any flanged joint.

3.8.2 On large joints, great energy may be stored in the flange unit components. Follow safe unbolting practices when disassembling flange joints as described below:

- Gradually untighten nuts in a star pattern as per Appendix G.
- Leave the nuts loosened on the studs until the joint has been separated.
- Anticipate pipe spring.

3.8.3 Ensure proper tag and lockout procedures are followed (see *Lockout and Tagout Procedure* (EDMS No. 3834759)).

4 TIGHTENING, TOOL SELECTION AND TOOL USE REQUIREMENTS

Unless otherwise noted, the Contractor or personnel performing the joint installation shall perform the following activities.

4.1 General Tightening Requirements

4.1.1 Tighten each of the studs using the sequence shown in Appendix G. Mark each stud with chalk or a grease pencil as it is tightened so it is easy to verify that all studs have been tightened.

4.1.2 Achieve the final torque value by tightening the flange in five stages as follows:

1. Initial recommended setting: 25% of maximum torque value
2. Second recommended setting: 50% of maximum torque value
3. Third recommended setting: 75% of maximum torque value
4. Full setting: 100% of maximum torque value
5. Check pass of 100% of target torque in clockwise fashion around the flange

4.1.3 Ensure manual and hydraulic/pneumatic torque wrenches as well as the pressure gauges on the pneumatic pump for the hydraulic tensioners are calibrated annually. Provide calibration records, including before and after reading for torque wrenches.

4.1.4 Flanges to be installed below ground shall be re-torqued as an additional check post achieving 100% of target torque after 4 hours (similar to a Check pass mentioned in section 4.1.2).

4.2 Tool Selection

4.2.1 Refer to Appendix A (Class 150/PN20), Appendix B (Class 300/PN50), Appendix C (Class 600/PN100), Appendix D (Class 900/PN150), Appendix E (Class 1500/PN250) and Appendix F (Class 2500/PN420) for the proper tightening tool and for the torque values to use with each tool.

4.3 Hammer Wrench

4.3.1 Use hammer wrenches only for loosening nuts.

4.3.2 Do not use hammer wrenches for completing the final tightening.

4.3.3 Do not use hammer wrenches for offshore/subsea applications.

4.4 Manual Torque Wrench

4.4.1 Use manual torque wrenches only for tightening bolts.

4.4.2 Do not use manual torque wrenches for loosening bolts.

4.5 Hydraulic/Pneumatic Torque Wrench

4.5.1 Hydraulic/pneumatic torque wrenches are preferred for tightening bolts and can also be used for loosinging bolts.

4.6 Hydraulic Tensioner

4.6.1 Hydraulic tensioners are preferred for tightening Class 600 (PN100), Class 900 (PN150) and Class 1500 (PN250) flanges NPS 16 and larger.

4.6.2 For the required bolt loading, see Appendix C (Class 600/PN100), Appendix D (Class 900/PN150), Appendix E (Class 1500/PN250) and Appendix F (Class 2500/PN420).

4.6.3 Use multiple tools for simultaneous tightening of bolts with diameters M20 (3/4 in.) and larger.

4.6.4 Calibrate pressure gauges on the pneumatic pump for the hydraulic tensioners annually. Keep records on file and provide them to the Company for project files.

5 VARIANCES

Any deviation shall follow the TransCanada Management of Change (MOC) Variance Procedure. External vendors must contact the TransCanada Project Engineer for variance approval.

6 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are detailed below in Table 6-1. Use the latest document revision, unless otherwise approved by TransCanada.

Table 6-1: External and Internal References

Document No.	Title
Regulatory Codes	
CFR 192.147	Design of Pipeline Components – Flanges and Flange Accessories
CFR 195.118	Design Requirements – Fitting
CFR 195.126	Design Requirements – Flange Connection
CFR 195.422	Operations and Maintenance – Pipeline Repairs
CSA Z662, 5.2	Steel Material and Gaskets
CSA Z662, 5.2.7	Bolting
CSA Z662, 5.2.8	Gaskets
CSA Z662, 10.5	Operating and Maintenance Procedures
Industry Codes and Standards	
ASME PCC-1 2013	Guideline for Pressure Boundary Bolted Flange Joint Assembly
ASME PCC-2 2015	Repair of Pressure Equipment and Piping
ASME B16.5	Pipeline Flanges and Flanged Assemblies
ASME B16.47 - 2011	Large Diameter Steel Flanges
ASME B18.2.2 - 2015	Nuts for General Applications
ASME BPVC	Section VIII Division 1 Mandatory Appendix 2
Internal References – Documents Referenced by this Standard / Specification	
EDMS No. 3671361	Asbestos Management Procedures Canada and Mexico
EDMS No. 3864096	Asbestos Management Procedures U.S.
EDMS No. 3670944	TES-CP-MS Cathodic Protection Materials Specification (CDN-US)
EDMS No. 7279729	Flange Installation Quality Control Form
EDMS No. 3834759	Lockout and Tagout Procedure
EDMS No. 3670944	TES-CP-MS Corrosion Prevention Material Specification

Document No.	Title
EDMS No. 3764909	TES-MATL-MD1 Piping System Materials for Pipeline, Compression and Metering Facilities
EDMS No. 7935312	TES-MATL-MD1-L Piping System Materials for Pipeline, Pump, Metering and Terminal Facilities (CDN-US-MEX)
EDMS No. 4471280	TES-MATL-MD1-US Piping System Materials for Pipeline, Compression and Metering Facilities (CDN-US-MEX)
EDMS No. 3671966	TES-FLGE-LD Specification for Carbon Steel Buttwelding Flanges

7 DOCUMENT HISTORY

Rev. No.		
03	**Description**	**Effective Date**
	Revised to reflect the new engineering specifications template, to ensure compliance to CSA Z662-15 and to update bolt torques in the Appendices.	2017-Feb-16
	Rationale Statement	**Responsible Engineer**
	This document was developed to address the following requirements: • Consolidation of specifications. The following specifications/documents have been combined into this document: ▪ TES-MECH-FBT Specification for Flange Assembly (CDN-US-MEX) Rev. 02 ▪ TOP: Flange Bolt tightening procedures • Formatted to the new engineering specifications template • Revised torque values and addied additional NPS sizes for appendix tables and added torque tables for ANSI 1500 and ANSI 2500 class flanges	Jason Lu
	Impact Assessment Summary	**Team Owner**
	N/A	Jason Lu

8 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
N/A	This Specification is a new document.

9 APPROVALS

APPROVALS		
Originator: David Scalzo, P.Eng. Design Services	Signature	Feb. 6, 2017 Date
Reviewer: Melissa Kuntel, P.Eng. Pipeline Engineering	Signature	FEB. 7, 2017 Date
Reviewer: Trent Bertholet, Welding & Materials Engineering	Signature	FeB 9, 2017 Date
Reviewer: Travis Dobbyn, Construction Manager CMS Projects & Operation US & Mexico	Signature	Feb 8/2017 Date
Reviewer: Dmitry Ryapolov, P.Eng. Valve Specialist, Technical Services	Signature #84006	Feb 9, 2017 Date
Responsible Engineer: Jason Lu, P. Eng. Design Services	Signature FEB. 09 2017 Date	PROFESSIONAL ENGINEER JASON S. LU ALBERTA APEGA Permit to Practice P7100
Management Endorsement: Muhammad Riaz, Manager Design Services	Signature	Feb. 13th, 2017 Date

APPENDIX A ANSI 150 (PN20) Bolt Tightening Requirements

Flange Size		Stud Bolts		Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method		Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	**Raised Face** Minimum Stud Length[3,4] In. (mm)	Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
0.5	4	1/2 (12.7)	2-3/4 (70)	7/8 (22)	P		35	25
0.75	4	1/2 (12.7)	3 (75)	7/8 (22)	P		35	25
1	4	1/2 (12.7)	3 (75)	7/8 (22)	P		35	25
1.25	4	1/2 (12.7)	3-1/4 (85)	7/8 (22)	P		35	25
1.5	4	1/2 (12.7)	3-1/4 (85)	7/8 (22)	P		35	25
2	4	5/8 (15.9)	3-3/4 (95)	1-1/16 (27)	P		60	45
2.5	4	5/8 (15.9)	4 (100)	1-1/16 (27)	P		60	45
3	4	5/8 (15.9)	4 (100)	1-1/16 (27)	P		65	45
4	8	5/8 (15.9)	4 (100)	1-1/16 (27)	P		60	45
6	8	3/4 (19.1)	4-1/2 (150)	1-1/4 (32)	P		105	80
8	8	3/4 (19.1)	4-3/4 (120)	1-1/4 (32)	P		110	80
10	12	7/8 (22.23)	5 (125)	1-7/16 (36.5)	P		165	120
12	12	7/8 (22.23)	5-1/4 (135)	1-7/16 (36.5)	P		165	120
14	12	1 (25.4)	5-3/4 (145)	1-5/8 (41)	P		245	180
16	16	1 (25.4)	5-3/4 (145)	1-5/8 (41)	P		245	180
18	16	1-1/8 (28.6)	6-1/4 (160)	1-13/16 (46)	P	A	355	260
20	20	1-1/8 (28.6)	6-3/4 (170)	1-13/16 (46)	P	A	355	260
24	20	1-1/4 (31.8)	7-1/4 (185)	2 (50)	A	P	500	365
26	24	1-1/4 (31.8)	9-1/2 (240)	2 (50)	A	P	500	365
30	28	1-1/4 (31.8)	10 (255)	2 (50)	A	P	500	365
34	32	1-1/2 (38.1)	11-1/2 (290)	2-3/8 (61)	A	P	885	650
36	32	1-1/2 (38.1)	12 (305)	2-3/8 (61)	A	P	885	650
42	36	1-1/2 (38.1)	12-1/2 (320)	2-3/8 (61)	A	P	885	650
48	44	1-1/2 (38.1)	13-1/2 (345)	2-3/8 (61)	A	P	885	650

Notes:

1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2. The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.3 was selected for Class 150 (Bolt stress equals 31,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers.
4) If planning to use hydraulic tensioning add 1.5x Stud Diameter to the minimum recommended stud length. Lstud = Lmin + 1.5 x Dia.stud

APPENDIX B ANSI 300 (PN50) Bolt Tightening Requirements

Flange Size		Stud Bolts		Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method		Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	**Rasied Face** Minimum Stud Length[3,4] In. (mm)	Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
0.5	4	1/2 (12.7)	3 (75)	7/8 (22)	P		35	25
0.75	4	5/8 (15.9)	3-1/2 (90)	1-1/16 (27)	P		60	45
1	4	5/8 (15.9)	3-1/2 (90)	1-1/16 (27)	P		60	45
1.25	4	5/8 (15.9)	3-3/4 (95)	1-1/16 (27)	P		60	45
1.5	4	3/4 (19.1)	4 (100)	1-1/4 (32)	P		105	80
2	8	5/8 (15.9)	4 (100)	1-1/16 (27)	P		60	45
2.5	8	3/4 (19.1)	4-1/2 (115)	1-1/4 (32)	P		105	80
3	8	3/4 (19.1)	4-1/4 (110)	1-1/4 (32)	P		105	80
4	8	3/4 (19.1)	4-1/2 (115)	1-1/4 (32)	P		105	80
6	12	3/4 (19.1)	5-1/4 (135)	1-1/4 (32)	P		105	80
8	12	7/8 (22.23)	6 (150)	1-7/16 (37)	P		165	120
10	16	1 (25.4)	6-3/4 (170)	1-5/8 (41)	P		245	180
12	16	1-1/8 (28.6)	7-1/4 (185)	1-13/16 (46)	P	A	355	260
14	20	1-1/8 (28.6)	7-1/2 (190)	1-13/16 (46)	P	A	355	260
16	20	1-1/4 (31.8)	8 (205)	2 (50)	A	P	500	365
18	24	1-1/4 (31.8)	8-1/4 (210)	2 (50)	A	P	500	365
20	24	1-1/4 (31.8)	8-1/2 (215)	2 (50)	A	P	500	365
24	24	1-1/2 (38.1)	9-1/2 (240)	2-3/8 (61)	A	P	885	650
26	28	1-5/8 (41.3)	11-1/2 (290)	2-9/16(65)	A	P	1140	835
30	28	1-3/4 (44.5)	12-3/4 (325)	2-3/4 (70)	A	P	1440	1060
34	28	1-7/8 (47.63)	13-3/4 (350)	2-15/16 (75)	A	P	1785	1310
36	32	2 (50.8)	14-1/4 (360)	3-1/8 (79)	A	P	2185	1605
42	32	1-5/8 (41.3)	14-1/2 (370)	2-9/16 (61)	A	P	1310	875
48	32	1-7/8 (47.63)	16-1/4 (415)	2-15/16 (75)	A	P	1785	1310

Notes:

1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2.The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.3 was selected for Class 300 (Bolt stress equals 31,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers.
4) If planning to use hydraulic tensioning add 1.5x Stud Diameter to the minimum recommended stud length. Lstud = Lmin + 1.5 x Dia.stud

APPENDIX C ANSI 600 (PN100) Bolt Tightening Requirements

Flange Size		Stud Bolts			Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method			Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	Minimum Stud Length[3,4] In. (mm) Raised Face	Minimum Stud Length[3,4] In. (mm) RTJ	Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Hydraulic Tensioning	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
0.5	4	1/2 (12.7)	3-1/2 (90)	4 (100)	7/8 (22)	P			50	40
0.75	4	5/8 (15.9)	4 (100)	4-1/2 (115)	1-1/16 (27)	P			100	75
1	4	5/8 (15.9)	4 (100)	4-1/2 (115)	1-1/16 (27)	P			100	75
1.25	4	5/8 (15.9)	4-1/4 (110)	4-3/4 (120)	1-1/16 (27)	P			100	75
1.5	4	3/4 (19.1)	4-3/4 (120)	5-1/4 (135)	1-1/4 (32)	P			170	125
2	8	5/8 (15.9)	4-3/4 (120)	5-1/4 (135)	1-1/16 (27)	P			100	75
2.5	8	3/4 (19.1)	5-1/4 (135)	5-3/4 (145)	1-1/4 (32)	P			170	125
3	8	3/4 (19.1)	5-1/2 (140)	6 (150)	1-1/4 (32)	P			170	125
4	8	7/8 (22.23)	6-1/4 (160)	6-3/4 (170)	1-7/16 (37)	P			270	200
6	12	1 (25.4)	7-1/4 (185)	7-3/4 (195)	1-5/8 (41)	P	A		400	295
8	12	1-1/8 (28.6)	8 (205)	8-1/2 (215)	1-13/16 (46)	P	A		590	435
10	16	1-1/4 (31.8)	9 (230)	9-1/2 (240)	2 (50)	P	A		825	605
12	20	1-1/4 (31.8)	9-1/4 (235)	9-3/4 (250)	2 (50)	P	A		825	605
14	20	1-3/8 (35)	9-3/4 (250)	10-1/4 (260)	2-3/16 (55)	P	A		1120	825
16	20	1-1/2 (38.1)	12-3/4 (325)	13-1/4 (335)	2-3/8 (61)		A	P	1475	1080
18	20	1-5/8 (41.3)	13-3/4 (350)	14-1/4 (360)	2-9/16 (65)		A	P	1900	1395
20	24	1-5/8 (41.3)	14-1/4 (360)	14-3/4 (375)	2-9/16 (65)		A	P	1900	1395
24	24	1-7/8 (47.6)	16-1/4 (415)	16-3/4 (425)	2-15/16 (75)		A	P	2975	2185
26	28	1-7/8 (47.6)	17 (430)	17-1/2 (445)	2-15/16 (75)		A	P	2975	2185
30	28	2 (50.8)	18 (455)	18-1/2 (470)	3-1/8 (79)		A	P	3640	2670
34	28	2-1/4 (57.2)	19-1/2 (495)	20 (510)	3-1/2 (89)		A	P	5255	3855
36	28	2-1/2 (63.5)	20-1/2 (520)	21 (535)	3-7/8 (98)		A	P	7295	5350
42	28	2-1/2 (63.5)	24 (610)	24-1/2 (620)	3-7/8 (98)		A	P	7295	5350
48	32	2-3/4 (69.9)	26-1/2 (675)	27 (685)	4-1/4 (108)		A	P	9800	7190

Notes:

1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2.The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.5 was selected for Class 600 (Bolt stress equals 52,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers. For RTJ flanges an additional a half inch was added to the stud length to accomidate the ringed gasket.
4) Extra long studs are used for NPS 16 to NPS 48 to accommodate the preferred use of hydraulic tensioning; a 1.5x Stud Diameter was added to the minimum stud length (Lstud = Lmin + 1.5 x Dia.stud).

APPENDIX D ANSI 900 (PN150) Bolt Tightening Requirements

Flange Size		Stud Bolts			Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method			Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	Minimum Stud Length[3,4] In. (mm)		Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Hydraulic Tensioning	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
			Raised Face	RTJ						
0.5	4	3/4 (19.1)	4-3/4 (120)	5-1/4 (135)	1-1/4 (32)	P			170	125
0.75	4	3/4 (19.1)	5 (125)	5-1/2 (140)	1-1/4 (32)	P			170	125
1	4	7/8 (22.23)	5-1/2 (140)	6 (150)	1-7/16 (37)	P			270	200
1.25	4	7/8 (22.23)	5-1/2 (140)	6 (150)	1-7/16 (37)	P			270	200
1.5	4	1 (25.4)	6 (150)	6-1/2 (165)	1-5/8 (41)	P			400	295
2	8	7/8 (22.23)	6-1/4 (160)	6-3/4 (170)	1-7/16 (37)	P			270	200
2.5	8	1 (25.4)	6-3/4 (170)	7-1/4 (185)	1-5/8 (41)	P			400	295
3	8	7/8 (22.23)	6-1/4 (160)	6-3/4 (170)	1-7/16 (37)	P			270	200
4	8	1-1/8 (28.6)	7-1/4 (185)	7-3/4 (195)	1-13/16 (46)	P	A		590	435
6	12	1-1/8 (28.6)	8 (205)	8-1/2 (215)	1-13/16 (46)	P	A		590	435
8	12	1-3/8 (34.9)	9-1/4 (235)	9-3/4 (250)	2-3/16 (55)	P	A		1120	820
10	16	1-3/8 (34.9)	9-3/4 (250)	10-1/4 (260)	2-3/16 (55)	P	A		1120	820
12	20	1-3/8 (34.9)	10-1/2 (265)	11 (280)	2-3/16 (55)	P	A		1120	820
14	20	1-1/2 (38.1)	13-1/2 (345)	14 (355)	2-3/8 (60)		A	P	1475	1080
16	20	1-5/8 (41.3)	14-1/4 (360)	14-3/4 (375)	2-9/16 (65)		A	P	1900	1395
18	20	1-7/8 (47.63)	16 (405)	16-1/2 (420)	2-15/16 (75)		A	P	2975	2185
20	20	2 (50)	17 (430)	17-1/2 (445)	3-1/8 (79)		A	P	3640	2670
24	20	2-1/2 (63.5)	21-1/4 (540)	21-3/4 (550)	3-7/8 (98)		A	P	7295	5350
26	20	2-3/4 (70)	22-1/2 (570)	23 (585)	4-1/4 (108)		A	P	9795	7185
30	20	3 (76.2)	24-1/4 (615)	24-3/4 (630)	4-5/8 (143)		A	P	12815	9400
34	20	3-1/2 (88.9)	27-1/4 (690)	27-3/4 (705)	5-3/8 (137)		A	P	20590	15100
36	20	3-1/2 (88.9)	27-3/4 (705)	28-1/4 (720)	5-3/8 (137)		A	P	20590	15100
42	24	3-1/2 (88.9)	30-1/2 (775)	31 (785)	5-3/8 (137)		A	P	20590	15100
48	24	4 (101.6)	34-1/4 (870)	34-3/4 (885)	6-1/8 (156)		A	P	31005	22740

Notes:

1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2.The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.5 was selected for Class 900 (Bolt stress equals 52,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers. For RTJ flanges an additional a half inch was added to the stud length to accomidate the ringed gasket.
4) Extra long studs are used for NPS 14 to NPS 48 to accommodate the preferred use of hydraulic tensioning; a 1.5x Stud Diameter was added to the minimum stud length (Lstud = Lmin + 1.5 x Dia.stud).

APPENDIX E ANSI 1500 (PN250) Bolt Tightening Requirements

Flange Size		Stud Bolts Nominal Size			Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method			Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	Minimum Stud Length[3,4] In. (mm) Raised Face	Minimum Stud Length[3,4] In. (mm) RTJ	Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Hydraulic Tensioning	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
0.5	4	3/4 (19.1)	4-3/4 (120)	5-1/4 (135)	1-1/4 (32)	P			170	125
0.75	4	3/4 (19.1)	5 (125)	5-1/2 (140)	1-1/4 (32)	P			170	125
1	4	7/8 (22.2)	5-1/2 (140)	6 (150)	1-7/16 (37)	P			270	200
1.25	4	7/8 (22.2)	5-1/2 (140)	6 (150)	1-7/16 (37)	P			270	200
1.5	4	1 (25.4)	6 (150)	6-1/2 (165)	1-5/8 (41)	P			400	295
2	8	7/8 (22.2)	6-1/4 (160)	6-3/4 (170)	1-7/16 (37)	P			270	200
2.5	8	1 (25.4)	6-3/4 (170)	7-1/4 (185)	1-5/8 (41)	P	A		400	295
3	8	1-1/8 (28.6)	7-1/2 (190)	8 (205)	1-13/16 (46)	P	A		590	435
4	8	1-1/4 (31.2)	8-1/4 (210)	8-3/4 (220)	2 (50)	P	A		825	605
6	12	1-3/8 (34.9)	10-3/4 (275)	11-1/4 (285)	2-3/16 (56)	P	A		1120	820
8	12	1-5/8 (41.3)	14-1/2 (370)	15 (380)	2-9/16 (75)		A	P	1900	1395
10	12	1-7/8 (47.6)	16-1/2 (420)	17 (430)	2-15/16		A	P	2975	2185
12	16	2 (50.8)	18-1/4 (465)	18-3/4 (475)	3-1/8 (79)		A	P	3640	2670
14	16	2-1/4 (57.2)	20 (510)	20-3/4 (525)	3-1/2 (89)		A	P	5255	3855
16	16	2-1/2 (63.5)	21-3/4 (550)	22-3/4 (580)	3-7/8 (98)		A	P	7295	5350
18	16	2-3/4 (69.9)	24-1/4 (615)	25-1/2(650)	4-1/4 (108)		A	P	9795	7185
20	16	3(76)	26-1/4 (665)	27-1/4 (690)	4-5/8 (117)		A	P	12815	9400
24	16	3-1/2 (89)	30 (760)	31-1/4 (795)	5-3/8 (137)		A	P	20590	15100

Notes:
1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2.The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.5 was selected for Class 1500 (Bolt stress equals 52,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers. For RTJ flanges an additional a half inch was added to the stud length to accomidate the ringed gasket.
4) Extra long studs are used for NPS 8 to NPS 24 to accommodate the preferred use of hydraulic tensioning; a 1.5x Stud Diameter was added to the minimum stud length (Lstud = Lmin + 1.5 x Dia.stud).

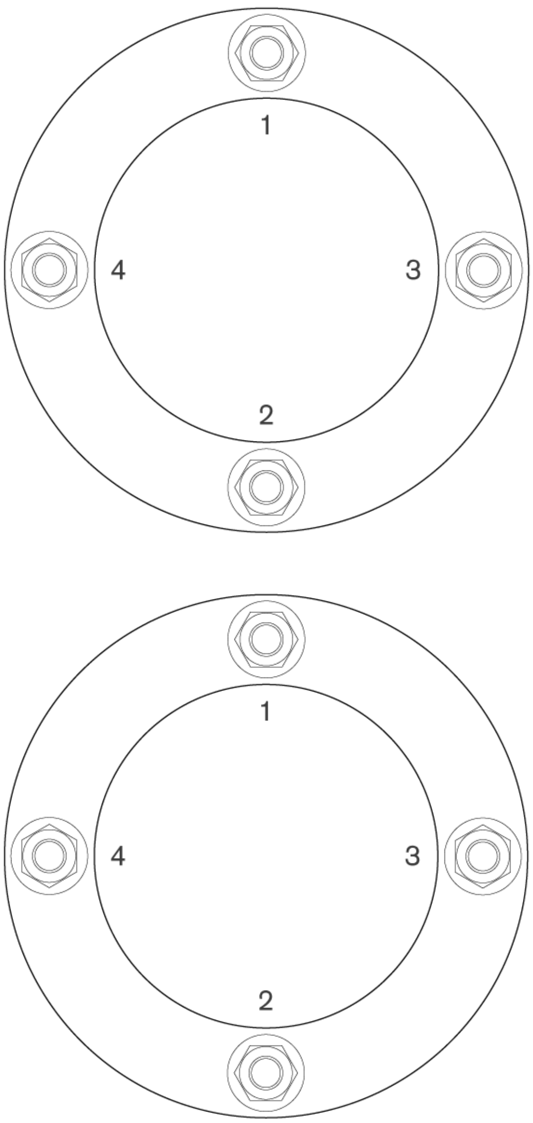
APPENDIX F ANSI 2500 (PN420) Bolt Tightening Requirements

Flange Size		Stud Bolts			Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method			Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	Minimum Stud Length[3,4] In. (mm) Raised Face	RTJ	Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Hydraulic Tensioning	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
0.5	4	3/4 (19.1)	5-1/4 (135)	5-3/4 (145)	1-1/4 (32)	P			170	125
0.75	4	3/4 (19.1)	5-1/2 (140)	6 (150)	1-1/4 (32)	P			170	125
1	4	7/8 (22.2)	6 (150)	6-1/2 (165)	1-7/16 (37)	P			270	200
1.25	4	1 (25.4)	6-1/2 (165)	7 (180)	1-5/8 (41)	P	A		400	295
1.5	4	1-1/8 (28.6)	7-1/4 (185)	7-3/4 (195)	1-13/16 (46)	P	A		590	435
2	8	1 (25.4)	7-1/2 (190)	8 (205)	1-5/8 (41)	P	A		400	295
2.5	8	1-1/8 (28.6)	8-1/4 (210)	8-3/4 (220)	1-13/16 (46)	P	A		590	435
3	8	1-1/4 (31.2)	9-1/4 (235)	9-3/4 (250)	2 (50)	P	A		825	605
4	8	1-1/2 (38.1)	12-3/4 (325)	13-1/2 (335)	2-3/8 (61)		A	P	1475	1080
5	8	1-3/4 (44.5)	15 (380)	15-1/2 (395)	3-1/8 (79)		A	P	2395	1760
6	8	2 (50.8)	17 (430)	17-1/2 (445)	3-1/8 (79)		A	P	3640	2670
8	12	2 (50.8)	18-1/2 (470)	19 (485)	3-7/8 (98)		A	P	3640	2670
10	12	2-1/2 (63.5)	23-1/2 (595)	24-1/4 (615)	4-1/8 (105)		A	P	7295	5350
12	12	2-3/4 (69.9)	26 (660)	26-3/4 (680)	1-1/4 (32)		A	P	9795	7185

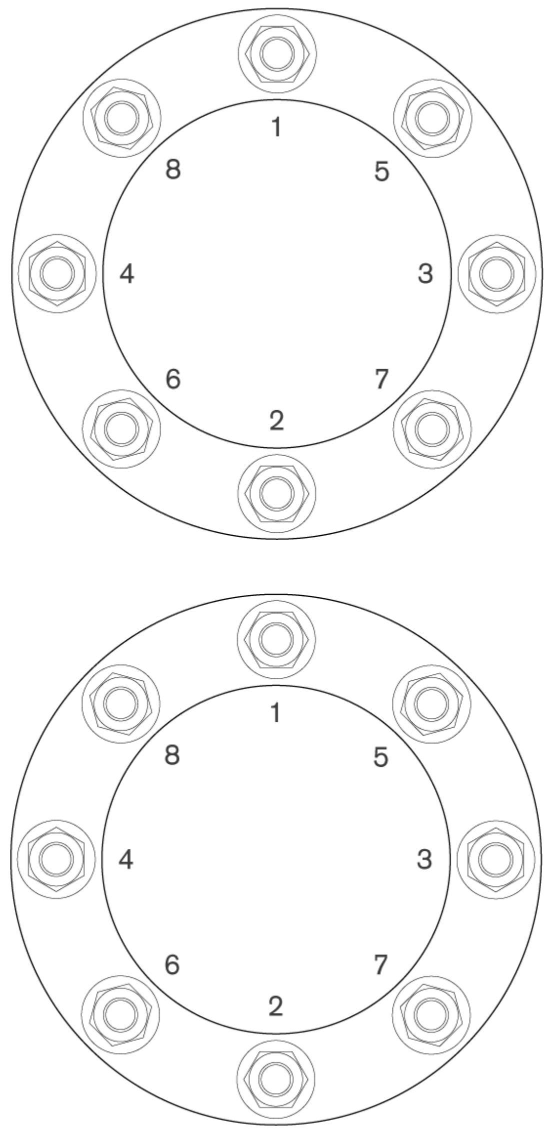
Notes:

1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2.The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.5 was selected for Class 2500 (Bolt stress equals 52,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers. For RTJ flanges an additional a half inch was added to the stud length to accomidate the ringed gasket.
4) Extra long studs are used for NPS 4 to NPS 12 to accommodate the preferred use of hydraulic tensioning; a 1.5x Stud Diameter was added to the minimum stud length (Lstud = Lmin + 1.5 x Dia.stud).

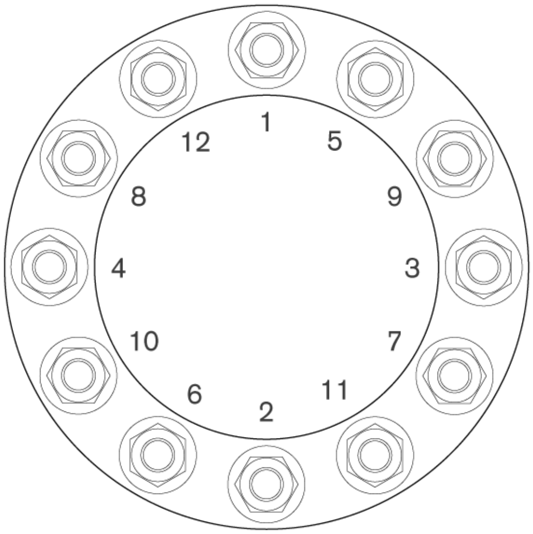
APPENDIX G TYPICAL STUD TIGHTENING SEQUENCE EXAMPLES

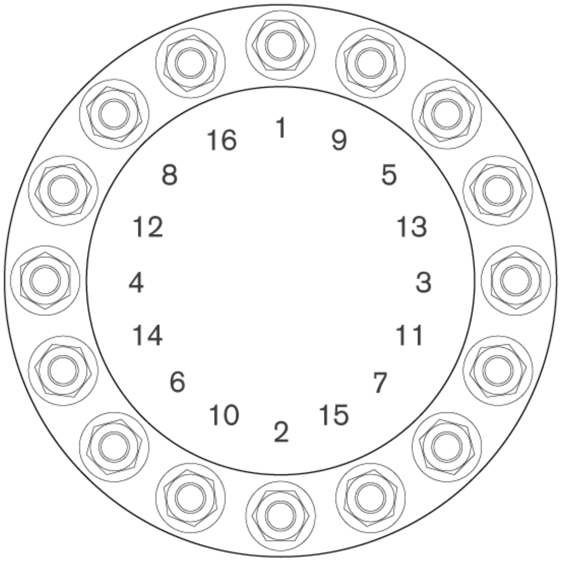


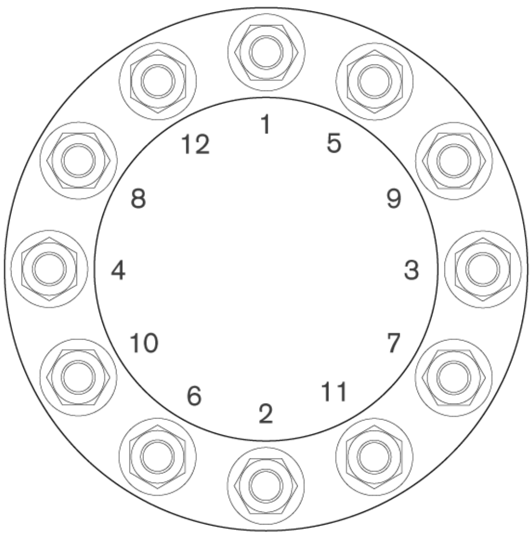
4 Stud Bolt Pattern

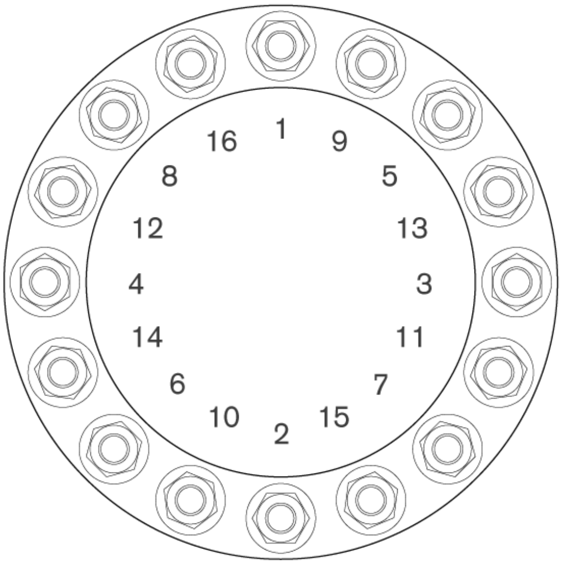


8 Stud Bolt Pattern



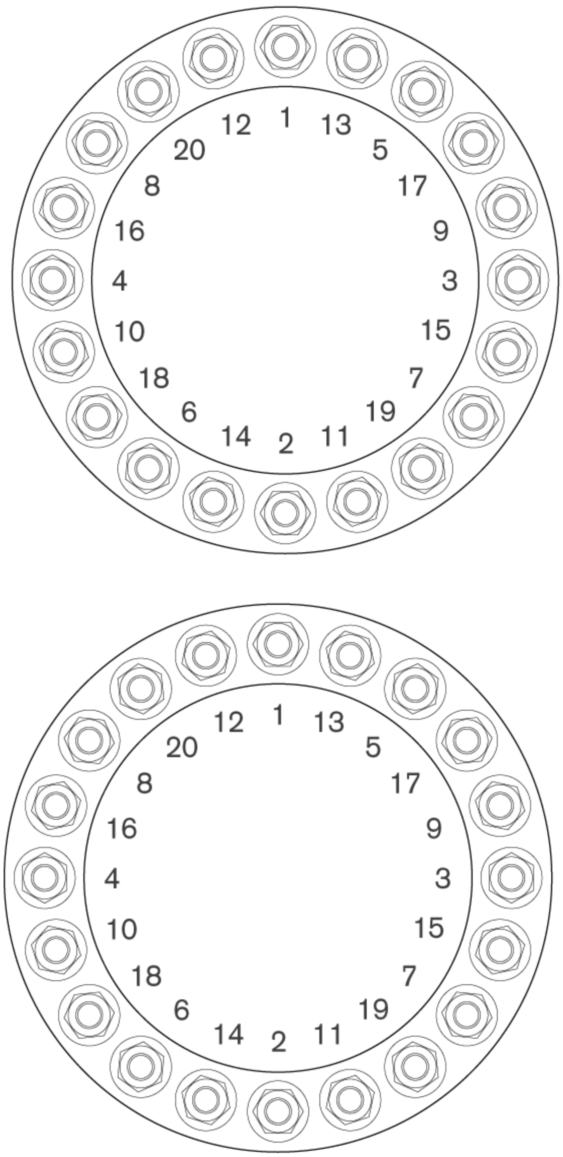




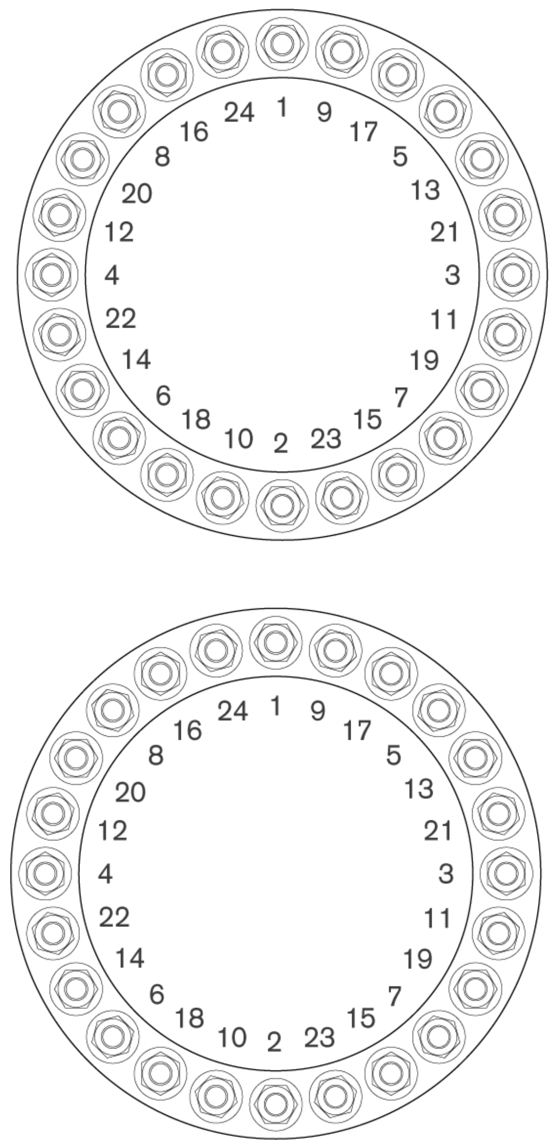


12 Stud Bolt Pattern

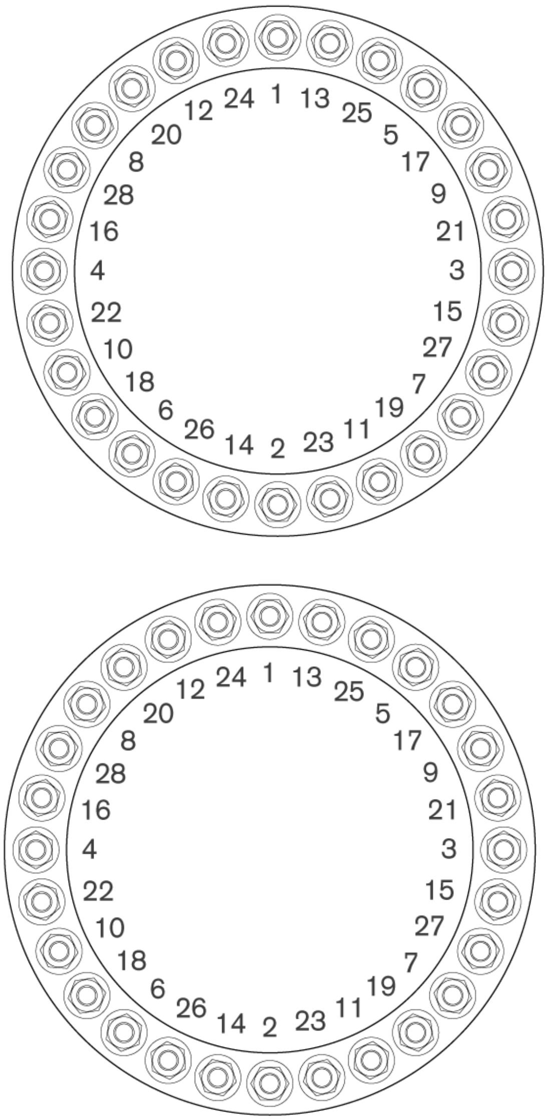
16 Stud Bolt Pattern



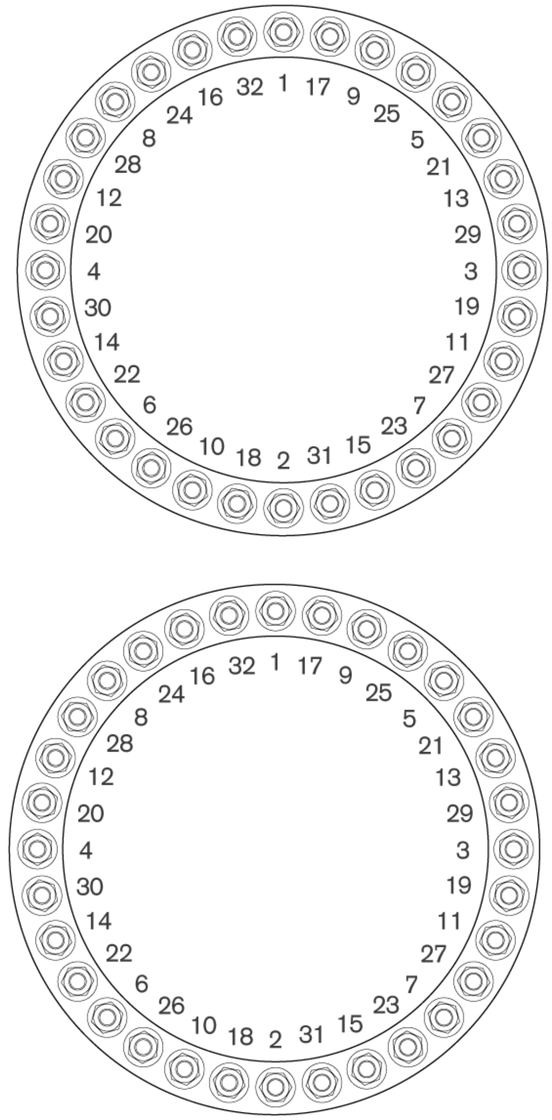
20 Stud Bolt Pattern



24 Stud Bolt Pattern



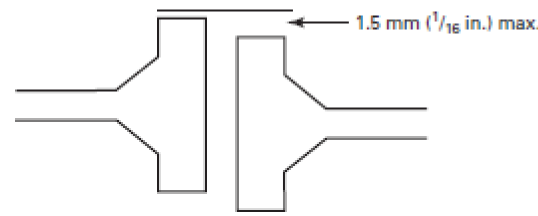
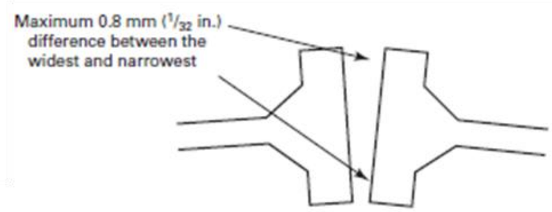
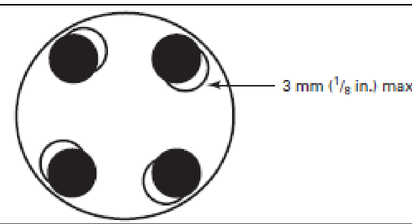
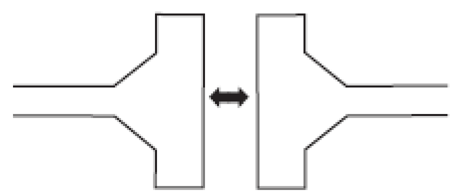
28 Stud Bolt Pattern



32 Stud Bolt Pattern

APPENDIX H FLANGE JOINT ALIGNMENT GUIDELINES

Table 9-1: Alignment Types[1]

Centerline high/low: the alignment of piping or vessel flanges so that the seating surfaces, the inside diameter of the bore, or the outside diameter of the flanges match or meet with the greatest amount of contact surface. Tolerance is usually measured by placing a straight edge on the outside diameter of one flange and extending it to or over the mating flange. This is done at four points around the flange, approximately 90 degrees from each other. The tolerance is 1.5 mm (1⁄16 in.) at any point.	
Parallelism: the alignment of piping or vessel flanges so that there are equal distances between the flange faces at all points around the circumference of the joint, therefore making the flange faces parallel to each other. The tolerance is usually determined by measuring the closest and farthest distance between the flanges and comparing. An acceptable practice is a difference no greater than 0.8 mm (1⁄32 in.) at the O.D. of the sealing surface, achieved using a force of no greater than 10% of the maximum torque or bolt load for any bolt.	
Rotational-two hole: the alignment of piping or vessel flanges so that the bolt holes align with each other, allowing the fasteners to pass through perpendicular to the flanges. The tolerance is measured by observing a 90-deg angle where the fastener passes through the flanges or the holes are within 3 mm (1⁄8 in.) of perfect alignment.	
Excessive spacing or gap: a condition where two flanges are separated by a distance greater than twice the thickness of the gasket when the flanges are at rest and the flanges will not come together using reasonable force. When no external alignment devices are used, the flanges should be brought into contact with the uncompressed gasket uniformly across the flange faces using less than the equivalent of 10% of the total target assembly bolt load. When aligning the flanges, no single bolt should be tightened above 20% of the single bolt maximum torque or target bolt load. When external alignment devices are used, the flanges should be brought to the compressed gasket thickness uniformly across the flange faces using an external load equivalent to less than 20% of the total target assembly bolt load. If more force is required to bring the flange gap into compliance, consult an engineer.	
[1] As defined in Appendix E of ASME PCC-1-2013	

PURPOSE

This Specification applies to gas meter stations for non-sour service and defines design and stress analysis requirements.

The objectives of this Specification are to ensure:

1. The meter station is defendable to the code to which it was designed.
2. The Company's operating experience has been communicated through the requirements, recommendations, and preferences.
3. The piping systems maintain structural integrity and optimization through a given range of operating conditions within the meter station.

SCOPE/APPLICABILITY

This Specification applies to the following in all divisions of the Company and its wholly-owned subsidiaries, and all operated entities/facilities in Canada (CAN), United States (U.S.) and Mexico (MEX).

Unless otherwise specified, the Authenticating Engineer(s) is the subject for all the considerations and requirements included in this Specification.

The Authenticating Engineer(s) is also responsible for ensuring that the meter station is defendable to the code to which it was designed.

This Specification applies to all pipe diameters, grades, and wall thicknesses within a meter station for the following piping systems:

- High Pressure Gas System
- Power Gas System
- Gas Vent System (high pressure)
- Utility Fuel Gas System (high pressure)

Note: Even though a formal pipe stress analysis is only required for the High-pressure gas system, all the other piping systems that apply to this Specification have to follow the requirements listed in this specification. It is the Authenticating Engineer's responsibility to determine whether or not other piping systems require formal analysis.

This Specification does not apply to the following piping systems within a meter station yard:

- compressed instrument air system
- utility fuel gas system (low pressure)
- HVAC System
- drainage system

- potable water system
- gas vent system (low pressure)
- fire suppression system (non-hydro)

This Specification does not apply to tubing.

Within this Specification, TransCanada is referred to as the Company.

Within this Specification, the following terms and definitions apply for requirements:

- Shall—expresses a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard. Shall is not a recommendation but a requirement.
- Should—expresses a strong preference, recommendation or that which is advised, but not required.
- Must—denotes a requirement of the Company, for which no deviation or variance would be granted.
- May—expresses an option or that which is permissible within the limits of the standard.
- Consider—assumes that a competent person will evaluate options to fulfill the intent of the requirement and make a documented decision supported by evidence to ensure protection of people, equipment, and the environment by achieving the appropriate level of functional integrity.

Wherein the Manufacturer's literature, governmental or regulatory requirements conflict with this Specification, the more stringent requirement shall govern.

The long-term operability, reliability, and maintenance of the entire system shall be considered when deviating from the requirements and recommendations denoted as a "Should". The direction to deviate from the denoted "Should" statement is provided in a document Authenticated by the Company's Engineer(s) and approved by the Company's Project Manager describing the new requirements and recommendations.

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GLOSSARY

Boundary conditions

The set of conditions used for the behavior of the solution to the model or analysis at the boundary of its domain. Boundary conditions are important in determining the mathematical solutions to the physical problem.

Competent

Qualified, trained, and experienced to perform the required duties.

Concrete pad

A flat concrete pad that pipe rests on to limit pipe settlement. Concrete pads are typically located underground.

Demonstrate

The use of documentation in the form of records, measurements, tests, comparisons, experiments, or analysis by a competent person to verify or explain a decision.

Expansion loop

A loop in pipe, made up of 4 elbows or bends that provides enough flexibility to absorb thermal expansion and reduce temperature-induced pipe stress and displacement to an acceptable level.

Expansion jog

An off-set in pipe made up of 2 elbows or bends that provides enough flexibility to absorb thermal expansion and reduce temperature-induced pipe stress and displacement to an acceptable level.

Ethafoam® 220

A soft foam material used to mitigate elevated forces and stress concentration.

Flange clamp

A full encirclement clamp encompassing the entire circumference of the flange.

Flange grab

A flat plate with holes drilled to match a flange that provides an attachment point for structural bracing. The flange grab can be on the larger diameter piping, the small diameter piping, piping attachments or branch connections. Where possible, it is preferable to have the plate between the nuts and the flange.

Flexibility

A piping system designed with enough flexibility for thermal expansion, thermal contraction, or other movement without causing excessive stress in the piping, components or equipment.

Full encirclement clamp

A support that encompasses the full 360° of the pipe.

Foam

Three types of foam have been referenced within the pipe stress analysis section of this specification. Ethafoam® 220 is a soft material to mitigate elevated forces and stresses concentration. A high density polyurethane foam box is used to structurally reduce the backfill weight and reduce settlement on small diameter piping.

Gross Vehicle Weight Rating (GVWR), or Gross Vehicle Mass (GVM)

The maximum operating weight or mass of a vehicle as specified by the manufacturer including the vehicle's chassis, body, engine, engine fluids, fuel, accessories, driver, passengers and cargo, but excluding that of any trailers.

Isolation medium

A plastic or elastomer material placed between the pipe and the supports used to stop any steel-to-steel contact or fretting corrosion, as well as isolate the supports from the cathodic protection circuit.

Large diameter piping

Piping that is greater than NPS 6 in outside diameter.

Piping attachments

Attachments with a diameter up to and including NPS 6 attached to the large diameter pipe such as instruments and pressure taps.

Polyurethane foam box

High density foam used to structurally reduce the backfill weight and reduce settlement on small diameter piping.

Saddle support

A support that encompasses 120° to 180° of the pipe.

SIF

Stress Intensity Factor

Sleeper support

A flat pad or plate made of concrete or steel on which the pipe rests.

Small diameter piping

Piping with an outside diameter up to and including NPS 6.

Sliding medium

A material placed at the bottom of a support to reduce the load on the pipe by way of reducing friction.

Soil ratcheting

A phenomenon where the buried pipe displaces when loaded due to temperature or pressure. This leaves a gap around the elbow fitting or bend, which is filled in with soil particles, preventing the pipe from returning to its original position after unloading.

Temporary

A period of less than 6 months mainly used for piping and supports utilized for transportation, construction and/or operational requirements.

Ultra High Molecular Weight Polyethylene (UHMW)

A plastic that is highly resistant to corrosive chemicals, has an extremely low moisture absorption, a very low coefficient of friction and is highly resistant to abrasion.

1 STRESS ANALYSIS CONDITIONAL REQUIREMENTS

1.1 General Stress Analysis Requirements

1.1.1 A comprehensive or a simplified piping stress analysis shall be conducted for new meter stations or brownfield projects within the meter station.

Clarification: If it can be determined based on competent engineering judgment that modifications to the piping or pipe support(s) affect neither the stiffness of the support structure nor the flexibility of the piping, a comprehensive piping stress analysis may not be required, but a simplified analysis is still required.

1.1.2 A comprehensive piping stress analysis shall be conducted for any meter stations with a pressure drop that would cause an operating temperature below 0°C (32°F). For belowground piping, that includes the effects of frost heave.

Clarification: Flexibility issues and frost heave may occur in piping that is operating below 0°C. Special backfilling requirement may need to be applied.

1.2 Pipe Stress Analysis (Comprehensive)

1.2.1 A comprehensive pipe stress analysis shall be performed for the meter station if one of the following criteria is met:

- inlet and outlet yard piping is NPS 8 or greater
- contains one or more sour bottle(s)
- contains an off-skid inlet separator
- contains a hot tap installation with a branch connection NPS 4 and greater

1.3 Pipe Stress Analysis (Simplified)

1.3.1 A simplified pipe stress analysis shall be performed where a comprehensive stress analysis is not required.

1.3.2 The following shall be used to perform a simplified pipe stress analysis:

- hand/manual calculations
- formulas
- charts
- visual inspection
- competent engineering judgment

1.3.3 Simplified stress analyses shall be documented and supplied to the Project Manager.

1.3.4 Piping, equipment sizes, pipe supports and layout for the entire meter station shall be considered and reviewed to ensure that the pipe support requirements outlined in sections of this specification have been achieved and that any areas of pipe stress concerns have been addressed.

1.4 Units of Measure

1.4.1 International System of Units (SI) shall be used for pipe stress analyses on meter stations located within Canada and Mexico.

1.4.2 Imperial Units shall be used for pipe stress analyses on meter stations located within the United States.

2 GENERAL PIPE SUPPORTING REQUIREMENTS

2.1 Station Location Requirements

2.1.1 Underground piping within the facility should not be installed through deep organic soil types or continuous or discontinuous permafrost unless considerations have been given to specific design mitigations to prevent settlement or heaving of the piping.

2.1.2 For meter stations situated in organic soil types, or continuous or discontinuous permafrost types of terrain, the Company's Stress Engineering and Geotechnical Engineering personnel should be contacted for a complete review, unless the Project Engineer and Project Manager accept responsibility for the design and the installation of the piping through the complex soil conditions.

2.2 General Requirements for Locating Pipe Supports

2.2.1 Supports should not be located under reducers, elbows or horizontal tees unless structural stress discontinuities and their effect have been considered.

Clarification: Supports can be placed under flanges, and vertical tees directly under risers for blowdowns and pressure relief(s).

Clarification: Beam analysis may not accurately predict the stresses within a fitting combined with structural loading and may grossly underestimate the level of stress.

2.2.2 Pipe supports should not be placed under pressure vessel or tanks inlets, outlets and other nozzles without consideration of the additional loading on the nozzles.

2.2.3 Pipe supports should be placed under valve flanges and other flange joints where possible.

Clarification: Unless needed for operations or other design requirements, flange joints do not need to be added to facilitate a support at a particular location.

Clarification: It is understood that there is some reluctance to install a support under a flange joint. However, a support placed under the flange would increase natural frequency of the piping system by supporting the greater body of mass, particularly for valves. The support would reduce the forces transferred through the circumferential weld joint, reducing the probability of weld joint indications (flaws) propagating. The flange joint support will give the indication that excessive stress is being demanded from the pipe system.

2.2.4 Sour bottles shall be supported by saddles or clamps to control lateral displacement.

2.2.5 Specialized anchor flange fittings shall be used to facilitate aboveground pipe anchors or line stops.

Clarification: Flange joints cannot be used as a pipe anchor or a line stop because the extra loads may cause leaks.

2.2.6 NPS 12 or larger valves that have flanges (flange x flange or weld x flange), should be supported at the flange(s) to increase the natural frequency of the piping system.

Clarification: The mass of a valve or other assemblies supported from the attached piping will increase the contact stresses on the piping as well as the increased static stress within the adjacent weld. Combined with dynamic stresses, this may be excessive.

2.2.7 Heavy masses should not be supported by the adjoining piping unless the increased excessive contact stresses and weld joint stresses have been considered.

Clarification: The mass of the valves or other assemblies supported from the attached piping increases stresses on the piping, and therefore decreases the capacity of pipe to handle other operations loads.

2.2.8 Pipe supports shall be placed under the belowground piping where the piping transitions from belowground to aboveground to reduce excessive pipe settlement and deformation of aboveground piping.

Clarification: Excessive settlement of the belowground piping where the piping transitions from belowground to aboveground has caused excessive contact stress and flange fit-up issues. Accounting for settlement of underground flanges may not meet the flange leakage requirements.

2.2.9 The edge of the pipe support shall be designed to be a minimum of one pipe diameter (1D) away from any pipe girth weld.

Clarification: The one pipe diameter (1D) requirement does not apply to when a support is placed under a fitting (i.e., flange or a vertically-oriented tee).

2.2.10 For situations where the edge of the pipe support is less than a half of one pipe diameter (0.5D) away from any pipe girth weld due to design or construction errors, the support or girth weld shall be relocated.

2.2.11 For situations where the edge of the pipe support is less than one pipe diameter (1D) away from any pipe girth weld but greater than half of one pipe diameter (0.5D) due to design or construction errors, the support or girth weld should be relocated.

Consideration: If the edge of support is less than one pipe diameter (1D) but greater than half of one pipe diameter (0.5D) away from any pipe girth weld, a detailed Finite Element Analysis (FEA) of the shell may be required to ensure that the axial and shear membrane stresses applied to the piping by the pipe support and auxiliary loads do not influence the maximum allowable weld defects by code. The pipe girth weld should be ultrasonically inspected and all the linear indications removed.

Clarification: The shear distribution pattern is not well understood in the area extending one pipe diameter (1D) on each side of the support, which has been referred to as the *fuzzy zone* by some references. When combined with any residual weld stresses, indication (flaws) in the weld joint, there is a probability/risk that the indications (flaws) within the weld joint may propagate given these factors. Even if a fatigue analysis was conducted, it does not cover fracture initiation points or stress risers from weld flaws.

2.3 General Design Pipe Support Requirements

2.3.1 All pipe supports designed, constructed and installed shall be approved by the Company's Stress Engineering and Structural/Civil personnel unless the Project Engineer and Project Manager accepts responsibility for the design, installation and localized stresses caused by structural discontinuities.

2.3.2 All pipe supports shall be designed, constructed and installed to be removed and reinstalled with a minimum amount of difficulties and effort as possible.

Clarification: All pipe supports need to be removable from the piping and base for maintenance and integrity purposes.

2.3.3 Structural supports shall not be directly welded to any piping or pressure containing components including welding on dummy legs, saddles, supports or gussets.

Exception: Structural supports may be welded to pressure containing components where the structural supports were designed, fabricated and attached to the pressure containing components by the original equipment manufacturer.

Clarification: Welding a fillet weld to the pipe is problematic because: 1) it causes a concentrated discontinuous stress in the pipe, and 2) the fillet weld joint cannot be inspected by full volume inspection techniques.

2.3.4 Clearance for a longitudinal or spiral weld seam shall be by way of a gap in the isolation medium between all piping and the supports.

Clarification: The isolation medium for sleeper, saddle and full encirclement clamp supports needs to provide clearance for the longitudinal or spiral weld seam by way of a gap. Grinding off the longitudinal or spiral weld seam on the pipe to accommodate a support is prohibited.

2.3.5 A saddle type pipe support should be placed under the belowground piping where the piping transitions from belowground to aboveground for piping NPS 6 and greater unless the potential for excessive localized contact stresses have been considered.

Clarification: Excessive settlement of the belowground piping where the piping transitions from belowground to aboveground has caused excessive contact stresses on the underground piping when sleeper supports have been used.

2.3.6 Sleeper support or sandbag placed on undisturbed soil may be specified under the belowground piping where the piping transitions from belowground to aboveground for NPS 2 or NPS 4, instead of a saddle support, depending contact stresses within the pipe.

Clarification: Directly cradling or encasing the pipe with concrete as a support is not recommended due to maintenance and integrity concerns.

2.3.7 Clamp type pipe supports should not be used for underground piping unless excessive restraining of the piping has been considered.

2.3.8 All saddle and clamp type pipe supports with non-sliding bases should be bolted to the structure and not welded.

Clarification: The bolting of the pipe support base is preferred over the welding of the support due to removability for visual inspection. Bolting is also more affordable than welding.

2.3.9 All sliding saddle and clamp type pipe supports with lateral and/or axial sliding capability used for large diameter piping should be restrained in the vertical direction to the support foundation by bolts and slotted or rounded bolt holes.

Clarification: Pipe supports not attached to the pile cap or concrete foundation have been known to slide off the base. Therefore, this is to ensure that the support will not slide out from under the piping.

2.3.10 All sliding pipe supports that require lateral and/or axial sliding capability for small diameter piping should be restrained to the large diameter piping or the support foundation by bolting unless the increased natural frequency of the piping system and the potential for structural stress discontinuities have been considered.

2.3.11 Consideration should be given to the adjustability of the pipe support (through shimming or other means) to ensure that the pipe support maintains full contact with the piping.

2.3.12 Temporary supports and piping should be physically marked as *TEMPORARY* on the asset and the drawings.

Clarification: Temporary supports and piping may be required for transportation, construction and short-term operations requirements.

2.3.13 Temporary supports and piping needed for short-term operations shall meet the code requirements.

2.3.14 All bolted connections used on pipe supports should have screw threads that conform to *ANSI B1.1 - American National Standards Institute - Screw Thread Standards,* unless the extra operational complexity of another screw thread has been considered.

Clarification: Using a standard bolt thread reduces operational complexity.

2.3.15 All bolted connections should be lockable by lock nuts, double nuts, castle nuts, lock washers or cotter pins.

Clarification: Bolts need to be prevented from vibrating loose.

2.4 Isolation Medium

2.4.1 Isolation medium should be used between all piping and supports.

Clarification: Isolation material is also required to reduce vibrations and noise reverberating through the piping system, and to reduce the probability of magnifying the noise and allowing the noise to attenuate along the pipeline at a low frequency. Also, the purpose of the isolation medium between the piping and supports is to prevent any hard surface-to-surface contact or fretting that can damage the coating as well as isolation of the cathodic protection (CP) circuit.

2.4.2 Isolation medium may not be required between the anchor flange and the support.

Clarification: Isolation material might hamper the installation and function of the anchor flange and is not required unless required for isolation of the cathodic protection (CP) circuit.

2.4.3 Isolation medium should be designed with a gap to accommodate the weld seam unless consideration has been given to the effects of the contact pressure on the weld seam.

Clarification: The gap to accommodate the weld seam will reduce the contact pressure on the weld seam.

2.4.4 The design thickness of the isolation medium should be enough to prevent fit-up issues due to pipe seam welds for a saddle or a clamp support.

2.4.5 Isolation medium between all piping and supports should be any of the following, unless the long-term functionality during installation and operations of another material has been considered:

- Polytetrafluoroethylene (PTFE)/Teflon
- Ultra-High Molecular Weight Polyethylene (UHMW)
- Neoprene (Durometer Shore Hardness between A65 to A85)

2.4.6 Isolation medium should be designed and used with a minimum thickness of the following unless the long-term functionality during installation and operations of another minimum thickness has been considered:

- 3.0 mm (0.13 in.) for NPS 1-1/2 and smaller
- 6.0 mm (0.25 in.) for NPS 2 and greater

2.4.7 The radius of a saddle or clamp shall be designed with consideration of the thickness and compressibility of the isolation medium.

Note: Some off-the-shelf pipe clamp products are designed exactly to the nominal pipe outside diameter and cannot fit a layer of isolation medium.

2.4.8 U-bolts should be coated with neoprene rubber or a sheet of neoprene rubber, both with a thickness of 3 mm (0.125 in) or greater unless the functionality of another type of material and thickness has been considered.

2.4.9 U-bolt clamps should use a 6.0 mm (0.250 in) thick neoprene rubber on the bottom plate unless the functionality of another type of material and thickness has been considered.

2.5 Sliding Medium

2.5.1 Sliding medium should be used between all sliding surfaces of the support, unless the long-term functionality of another method has been considered.

2.5.2 Steel-to-steel or concrete-on-steel sliding surfaces should not be used, unless consideration has been given to determining the long-term functionality of the coefficient of friction, and determining the coefficient of friction experientially under multiple environmental conditions.

Clarification: The use of steel-to-steel or concrete-on-steel sliding surfaces has been found to be problematic during operations within the lifetime of the asset. The steel-to-steel surface rusts and forms a bond over a period. On the concrete-to-steel surface, the concrete has been found to crack or degrade over time. The increased friction has caused the neoprene to work its way out of the support causing coating damage and cathodic protection (CP) issues. It is recommended that the steel-to-steel or concrete-on-steel sliding surfaces be modelled with a range of friction coefficient, depending on the surface roughness expected over the life of the support.

2.5.3 Sliding medium required for sliding supports should be designed to encompass the entire base plate surface area of the sliding support.

Clarification: The longevity of small areas of sliding medium is dependent on the contact pressure. To increase the longevity, the surface area of the sliding medium needs to be maximized. The use of sliding medium with high contact pressures or thin sliding medium attached/bonded (glued) to steel plates has become a problem due to the wearing down of the sliding medium causing operational issues.

2.5.4 Sliding medium should not be pre-attached or bonded (glued) to thin steel plates or the support, unless consideration has been given to the degradation of the bond strength, the operability over time and the added cost.

Exception: Sliding medium pre-attached or bonded (glued) to washers or plates that cover slotted or rounded bolt holes due to the low contact pressures.

Clarification: The use of sliding medium pre-attached/bonded (glued) to thin steel plates, which are welded to the support, have caused problems with the welds cracking and the thin steel plates working themselves loose and sliding out from under the support.

2.5.5 Acceptable isolation medium for the base plate-sliding surface should be one of the following, unless consideration has been given to the long-term functionality of the coefficient of friction and determining the coefficient of friction experientially under multiple environmental conditions of another material such as:

- Teflon-to-Teflon
- Teflon-to-Steel

- UHMW-to-UHMW
- UHMW-to-Steel

Note: Ultra-High Molecular Weight polyethylene (UHMW)

2.5.6 Care should be taken to ensure that all belowground sliding supports are operational after backfilling.

2.5.7 The slotted bolt holes for the belowground sliding support should be filled with light foam or covered with oversized plate washers to prevent soil from entering and affecting the operability of the support.

2.5.8 The belowground sliding support should be protected by wrapping with foam and Denso tape to ensure operability, unless the long-term operability of other methods have been considered.

2.5.9 All belowground and aboveground sliding supports should be reviewed and approved by the Company's Stress Engineering and Structural/Civil personnel, unless the Project Engineer and Project Manager accepts responsibility for the support design, installation and long-term operability of the support.

3 DESIGN REQUIREMENTS FOR PIPE SUPPORTS CONFIGURATION

3.1 Saddles and Full Encirclement Clamps

Recommendation: Full encirclement clamp type pipe supports are recommended to reduce mechanical vibrations and reverberation, and to hinder potential noise attenuation along the piping. It is recommended to use full encirclement clamp type pipe supports in locations affected by mechanical vibration or with gas flow velocities greater than 21 m/s (68.8 ft/s) for an extended period of time.

3.1.1 The thickness of the steel full encirclement clamp or steel saddle utilized on the pipe should have a minimum thickness of the following, unless consideration has been given to the stiffness and function of a thinner clamp:

- 9.5 mm (0.375 in) for pipe sizes NPS 6 to NPS 12
- 12.7 mm (0.50 in) for pipe sizes NPS 16 to NPS 24
- 19 mm (0.75 in) for pipe sizes above NPS 24

Clarification: The thickness of the support is required to reduce the amount of shell flexibility in the piping.

3.1.2 The full encirclement clamp or steel saddle should have a minimum length along the axis of the pipe of the following, unless consideration has been given to the added local stresses, stiffnesses, and function of a saddle with a lesser width:

- 1/3 of one pipe diameter (0.33D) for pipe size greater than NPS 12
- 100.0 mm (4.000 in) for pipe size NPS 4 to NPS 12

Clarification: The length of the support is required to reduce the amount of rotation of the piping about the support.

3.1.3 A saddle support contact should be equal to or greater than 120° and less than or equal to 180°, unless the localized stresses caused by structural discontinuities have been considered for a saddle support with a different contact.

3.1.4 Full encirclement clamps should be used to contact or encompass at least 90% of the entire circumference of the pipe.

Clarification: The remaining 10% of the circumference allows for the gap in the clamp for tightening.

Note: There may be slight gaps between the pipe and the clamp which should be viewed as a concern with construction quality.

3.1.5 Full encirclement clamp supports and saddles should be fully removable by unbolting.

Clarification: The surface under the isolation medium/full encirclement clamps is an area that is susceptible to atmospheric corrosion because of the potential for aqueous environmental conditions between the isolation medium and the internal surfaces (pipe and/or clamp). Periodic visual inspection is required for maintenance and integrity purposes.

3.2 Point Contact Supports

3.2.1 Pipe supports with a single or multiple contact point(s) should not be used unless the possibility of an excessive contact pressure caused by structural discontinuities, known to cause dents, has been considered.

Clarification: Half-round circular type pipe supports that have a single or multiple contact point(s) have a very low capacity to support loads, due to the excessive contact pressure, and have been known to cause dents.

3.3 Linear Contact Supports

3.3.1 Pipe supports with a single linear contact (sleeper) or multiple linear contacts (double wedge) may be used as long as the supports meet the allowable criteria for membrane stress.

Clarification: Multiple linear contacts or a double wedge pipe support have two adjustable wedges on either side of the pipe.

3.3.2 Single linear contact type (sleeper) supports used belowground should have a minimum contact length of one pipe diameter (1D), unless the contact stresses and interaction between the stresses at the edge of the contact interacting with each other have been considered for a lesser contact length.

Clarification: With a narrow linear contact length, the stress concentrations on the pipe at the edge of the support will interact with each other, further reducing the capacity of the pipe to resist denting.

3.3.3 Multiple linear contact type supports should not be used to support belowground pipe, unless increased restraint and potential for increased contact stresses caused by structural discontinuities and the increased load on the pipe from the backfill have been considered.

3.3.4 Single (sleeper) or multiple linear contact type supports used aboveground should have a minimum contact length of half of one pipe diameter (0.5D), unless potential for increased contact stresses caused by structural discontinuities and interaction between the stresses concentration at the edge of the contact have been considered for a lesser contact length.

3.4 Flange Supports

3.4.1 A flange support may be a saddle or a beam under the flange joint.

3.4.2 Flange supports should not interfere with the bolting process or obstruct access to the flange bolts, unless the potential for obstructed access to the bolts has been considered in the design.

3.4.3 Flange supports should be a saddle when there is a concern for lateral displacement or vibration.

Clarification: The preference is to cradle the flange in a saddle, rather than having the flange sitting on a beam when there is a concern for lateral displacement or vibration.

Exception: It is acceptable to have the flange sitting on a beam for ultrasonic and orifice meters.

Clarification: Ultrasonic meters and orifice meters are supplied with anti-roll features and cannot be supported by a saddle. A beam-type support is required to support flanges with anti-roll features. Anti-roll features are required to transport meters for inspection and calibration.

3.5 Requirement for Flange Grabs Used for Bracing

Note: A flange grab is a steel plate that is bolted to the outside of the flange joint that can be used to provide support to the piping, where a flange clamp is a clamp that fully encircles the flange joint.

3.5.1 The weight of valves for NPS 12 or larger shall not be supported with a flange grab.

3.5.2 Pipe clamps and flange clamps utilized for bracing should be constructed from the following, unless consideration has been given to the stiffness effects of a thinner thickness:

- a minimum of 6.0 mm (0.25 in.) thick material for pipe sizes up to NPS 1-1/2
- a minimum of 9.5 mm (0.38 in.) thick material for pipe sizes from NPS 1-1/2 up to and including NPS 6
- a minimum of 12.7 mm (0.5 in.) thick material for pipe sizes greater than NPS 6

3.5.3 Flange grabs attached to the branch connection piping should be constructed from at least the following, unless the consideration has been given to the stiffness effects of a thinner thickness:

- a minimum of 12.0 mm (0.50 in.) thick plate for NPS 3/4 to NPS 6 branch connections
- a minimum of 19.0 mm (0.75 in.) thick plate for branches larger than NPS 6

Clarification: Due to the mass of some small diameter flanged-by-flanged valves, it is not uncommon to install a flange grab or support on both sides of the small diameter valves.

3.6 U-Bolt Clamps

3.6.1 U-bolts or U-bolt type clamps should not be used for piping greater than NPS 2, unless the increased rotational flexing of the piping system, decreased vibrational dampening capabilities, and the increased contact stress due to the structural discontinuities have been considered.

3.6.2 U-bolts or U-bolt type clamps shall not be used on large diameter piping to provide structural restraint bracing for small diameter piping, piping attachments and branch connections.

3.6.3 U-bolts used for clamping and supporting piping shall be kept to a minimum.

Clarification: Circumference pipe clamps are preferred over the use of U-bolts to stop rotational displacement, which pivots about the U-bolt support.

3.6.4 U-bolts shall be used in pairs with a minimum separation of one diameter (1D).

3.6.5 U-bolts shall not be used to support the weight of the pipe.

3.6.6 U-bolts shall not be over tightened.

Clarification: Overtightening is defined as the U-bolt cutting into the isolation medium (neoprene) causing the isolation medium to protrude between the piping and the U-bolt, leading to a loose fit and fretting damage.

3.7 Spring Supports

3.7.1 Spring supports or constant spring hangers should not be used for general support design unless the increased flexibility of the piping system, decreased natural frequency and the increased flexing of the pipe walls has been considered.

Exception: The exception is for the movement of piping due to the rotation of a tank nozzle caused by bulging and settlement in accordance with *API-650- Welded Tanks for Oil Storage*.

Note: Tanks are sometimes used in gas handling operations.

3.7.2 The use of any spring supports or constant spring hangers for piping should be reviewed and approved by the Company's Stress Engineering and Structural/Civil personnel, unless the Project Engineer accepts responsibility for the design, sizing, installation, and utilization of spring supports or constant spring hangers.

3.8 Anchors/Line Stops

3.8.1 Aboveground pipe anchors or line stops should be attached to a specialized anchor flange fitting.

3.8.2 The use of anchors in the design should be avoided where possible.

3.8.3 Axial displacement of the pipe should be controlled by adding elbows to the piping system (i.e., expansion loops or jogs) to increase flexibility.

3.8.4 Aboveground pipe anchors or line stops shall not be attached to flange sets.

Clarification: A pipe anchor or line stop attached to flange sets may cause a leak or prevent the flange from meeting the flange leakage requirements.

3.8.5 Anchors or line stops shall not be welded, bolted, or attached to elbows, tees or piping.

Clarification: To reduce the risk from indications (flaws) within the fillet weld joints propagating through the weld joint or the piping, the weld joint should be inspected by full volume techniques. To facilitate a welded anchor or line stop, a fillet weld joint is required, which cannot be inspected by full volume techniques. The use of bolted anchors or line stops has been found to be problematic during operations within the lifetime of the asset (e.g., bolts coming loose, slippage of the anchor due to inadequate compressive loads for the anchor load, anchor loads being under estimated).

3.8.6 Belowground pipe anchors or line stops should not be used on piping without considering structural stiffness requirements and constructability issues to meet design requirements and operational inspection requirements.

Clarification: The structural requirements for a belowground pipe anchor would be the same as an aboveground pipe anchor or line stop.

3.8.7 Anchors or line stops should not be directly cradled or encased in concrete without considering operational inspection requirements.

Clarification: Cradling or encasing pipe does not meet maintenance and integrity requirements that pipe supports need to be removable for inspection.

3.8.8 The foundation design for an anchor shall consider the effects of soil creep if the foundation is not deep enough, using pilings.

3.9 Concrete Supports

3.9.1 A concrete pad may be used as a sleeper type support if the pad is in continuous contact with the pipe over a minimum of one pipe diameter (1D) of the pipe length.

3.9.2 Concrete supports should not directly cradle or encase the carrier pipe or any other pressure-containing components without considering operational inspection requirements, coating protection, and cathodic protection (CP).

Clarification: Pipe supports must be removable for inspection; cradling or encasing pipe does not meet maintenance or integrity requirements.

3.10 Soil Compaction

3.10.1 Compaction should be specified for all underground elbows, tees, hot taps and valves, especially at belowground and aboveground transitions to reduce the consequences if there is a lack of supporting soil.

3.10.2 Compaction should be specified on both sides of an installed underground support if over-excavation is expected, unless the potential for excessive contact stresses has been considered.

3.10.3 A written compaction plan or procedure shall be provided with reasonable expectations based on competent engineering judgment.

3.10.4 All of the following shall be provided on project-specific drawings:

- compaction area boundaries
- reference to the written compaction plan or procedure

Clarification: Relying on general backfilling specifications to define compaction control has been problematic in past construction projects. Defining the compaction objective and location in the drawings will reduce issues at time of construction.

3.10.5 Flowable fill may be used in isolated cases, if coating protection and cathodic protection (CP) have been considered.

3.10.6 Flowable fill shall not be within 152 mm (6 inches) from the bottom or side of the pipe.

3.10.7 Flowable fill shall not be within 304 mm (12 inches) from the top of the pipe and placed on well compacted backfill.

3.10.8 The Company's Stress Engineering and Structural/Civil personnel should review and approve the use of fillcrete/flowable fill as a pipe support, unless the Project Engineer accepts responsibility for the use of the fillcrete/flowable fill.

3.10.9 If fillcrete/flowable fill is to be used, a testing process, which includes mechanical material testing, should be developed to ensure the fill meets the intended requirements.

3.11 Supports Spacing for Aboveground Piping

3.11.1 Unless the effects of mechanical vibration, the natural frequency of the piping system (shell and beam modes), reduced susceptibility for vortex shedding and increased contact stresses have been considered, the allowable support spacing for aboveground piping should consider whichever of the following methods yields the shortest free span length:

1. The associated piping membrane stresses combined with the circumferential and longitudinal stresses do not exceed allowable stress limits.
2. The spacing equation:

$$Spacing(m) = 0.33 \cdot \sqrt{D(mm)} \qquad Spacing(ft) = 5.51 \cdot \sqrt{D(in)}$$

Where:

D = outside piping diameter

Reference: Kormann, P. and Zhou, J. June 25-28, 1995. *Support Spacing of Buried and Above-Ground Piping, Second International Conference, Advances in Underground Pipeline Engineering*. American Society of Civil Engineers, Bellevue, Washington.

3.11.2 The spacing may need to be reduced based on elbows, tees and heavy piping components.

3.11.3 The distance between supports should include the length of elbows, tees and other fittings, unless the influence of length of fittings on the natural frequency of the piping system and the increased stiffness has been considered.

Clarification: The objective is to increase the natural frequency high enough to avoid large amplitude response under any slight perturbing force.

3.11.4 Small diameter piping may be supported alongside steel I-beams or large diameter piping to reduce the number of single support foundations.

3.11.5 Terminating valves or blind flanges at the end of a continuous horizontal run of pipe should be supported at the valve or flange unless the increased flexibility of the piping system has been considered.

Clarification: Cantilevering a valve or flange off of the end of a pipe run will have a very low natural frequency and potentially cause cyclic fatigue under the right conditions.

3.11.6 Allowable distance piping cantilevered off of the end of a continuous run pipe should not exceed the values shown in Table 3-1.

Table 3-1: Cantilevered Spacing at the End of Continuous Piping for NPS 3/4 to NPS 2

Pipe Size	Maximum Span from Support (m)	Maximum Span from Support (ft.)
NPS 3/4	0.27	0.8 (9 inches)
NPS 1 to NPS 2	0.31	1.0 (1 foot)

3.12 Supporting Cantilevered Aboveground Small Diameter Piping Connections Requirements

3.12.1 Allowable support distance for aboveground small diameter piping cantilevered off the large diameter piping without a supporting restraint shall be used not to exceed:

$$Spacing(m) = 0.029 \cdot \sqrt{D(mm)} \qquad Spacing(ft) = 0.486 \cdot \sqrt{D(in)}$$

Where:

D = outside piping diameter

See Table 3-2 for cantilevered spacing calculated for NPS ¾ to NPS 6.

Table 3-2: Cantilevered Spacing Calculated for NPS ¾ to NPS 4

Pipe Size	Maximum Span from Support (m)	Maximum Span from Support (ft.)
NPS 3/4	0.12	0.42 (5.00 in.)
NPS 1	0.14	0.48 (5.50 in.)
NPS 1 1/2	0.18	0.59 (7.00 in.)
NPS 2	0.20	0.68 (8.00 in.)
NPS 3	0.25	0.84 (10.00 in.)
NPS 4	0.29	0.97 (11.00 in.)
NPS 6	0.30	1.00 (12.00 in.)

3.12.2 Piping cantilevered off the large diameter piping should be greater than NPS 3/4.

3.12.3 Valves, flanges, blind flanges, or other masses attached to large diameter piping should be designed to be fully supported, unless the reduction of the stress discontinuities at the base of the attachment has been considered.

Exception: Needle valves or tubing fittings cantilevered off the large diameter piping.

4 ACCEPTABLE STRESS MITIGATION METHODS REQUIREMENTS

4.1 Expansion Joint(s)

4.1.1 Expansion joint(s) should not be used on the piping systems that are covered by this Specification, unless consideration has been given to the long-term operating requirements.

4.2 Thermal Expansion Loops

4.2.1 Piping flexibility from thermal or other expansions should be provided using a piping offset using two elbows (i.e., expansion jog).

4.2.2 Aboveground and belowground vertical oriented expansion loops (consisting of four elbows) should not be utilized, without considering the reduced natural frequency of the piping system and access issues during operations.

Clarification: Vertically-oriented expansion loops are difficult to support following the support criteria of this Specification. Aboveground vertically oriented expansion loops have been known to have a very low natural frequency and could be a cause for cyclic fatigue due to wind.

4.2.3 Belowground horizontally oriented expansion loops (consisting of four elbows) should not be utilized without taking into consideration future site usage, space concerns, future excavation clearances, design requirements, additional welding, permanent soil displacements and soil voids.

Clarification: Over time, backfill will consolidate around the piping restricting displacement of the belowground horizontally-oriented expansion loop so in the long-term, the expansion loop does not function as designed.

4.2.4 Aboveground horizontally oriented expansion loops (U-bends) may be utilized for mitigation from thermal and seismic issues.

4.3 Void Form Expansion Medium

4.3.1 Expansion medium may be used to mitigate isolated areas of concentrated stress or displacement for belowground piping.

4.3.2 The acceptable expansion medium for mitigating isolated areas of concentrated stress due to thermal expansion of short sections of underground piping and fittings should be Ethafoam® 220.

4.3.3 Any other types of expansion medium shall be approved by the Company's Stress Engineering personnel or Project Engineer.

4.3.4 Expansion medium should be a sheet type.

4.3.5 Sheet type expansion medium should be punched with 13.0 mm (0.5 in.) holes at a maximum of 100.0 mm (4.0 in.) on centres lengthwise and widthwise for considerations of the permeability of the cathodic protection (CP).

4.3.6 Expansion medium should be designed to a maximum compressive deflection of 25% of the material thickness.

4.3.7 Expansion medium at risers should be designed to end aboveground and at the middle of the elbow belowground.

4.3.8 Expansion medium should not be used under the pipe, at the base of the pipe or wrapped around the pipe, unless the analysis can demonstrate that the extra settlement has been considered.

4.3.9 Spray-applied expansion medium should not be used, unless the long-term functionality and expansion of the material under uncontrolled environmental conditions has been considered and addressed.

Clarification: Spray-applied expansion medium applied under uncontrolled environmental conditions has been known to have issues for long-term reliability.

4.3.10 Expansion medium on elbows and other piping locations should not be used for aboveground piping, unless long-term degeneration due to environmental conditions has been considered.

4.3.11 Expansion medium should not be used on straight sections of underground piping for lengths greater than 5.0 m (16.4 ft).

Clarification: The expansion medium is most effective at bends and tees, but the effectiveness diminishes with distance from directional changes in the piping.

4.3.12 Expansion medium should not be used within an area where the pipe would be stressed by vehicular loading within a designated paved or gravel access road or laneway, unless the effect of the vehicular loading on the material has been considered.

5 SURFACE LOADING REQUIREMENTS

5.1 Vehicular Travel Crossing Requirements

5.1.1 Belowground pipe fittings should not be located within an area where the pipe would be stressed by vehicular loading greater than the Gross Vehicle Weight Rating (GVWR) of 4000 kg (9000 lbs), such as a paved or gravel access road or laneway.

Clarification: Heavy vehicles on a sustained vehicle crossing could cause prolonged and unaccounted stresses.

5.1.2 Belowground pipe fittings should be at least horizontally the same distance as the dimension for the design Depth of Cover (DoC) of the piping from a paved or gravel access road or laneway.

5.1.3 Piping crossings below a paved or gravel access road should be designed so that the angle between the centreline of the sustained vehicular travel surface being crossed and the centreline of the pipe is as close to 90° as possible, but not less than 75°.

5.1.4 Belowground piping that parallels a sustained vehicular paved or gravel access road should be designed with a separation from the edge of the travel surface to the edge of pipe greater than 7.0 m (23.0 ft).

Clarification: The 7.0 m (23.0 ft) allows for vehicles to travel off of the travel surface and space for maintenance and integrity purposes.

5.1.5 The crossings calculation for sustained vehicular travel and other types of vehicular travel surfaces should be conducted in accordance with *API 1102, American Petroleum Institute Steel Pipelines Crossing Railroads and Highways,* or *CEPA, Canadian Energy Pipeline Association Surface Loading Calculator.*

Clarification: The validation of pipe stress with other crossings method may be difficult to defend.

5.1.6 Belowground piping shall be designed to support the sustained maximum vehicular highway loads for the location.

5.1.7 Vehicular details for traffic loads greater than the maximum vehicular highway load for the location may be provided by the Project Manager, if greater vehicular traffic loads are expected.

Note: In some location, the wall thickness and grade for the underground piping may be governed by the stress caused by vehicular loading.

5.1.8 Pipe sections under a vehicular travel surface shall be calculated at both zero pressure and maximum pressure.

Clarification: Ring deflection calculations are required to ensure integrity for the unpressurized case.

6 PIPE STRESS ANALYSIS MODEL

6.1 General Requirements

6.1.1 Competent engineering judgment used for the analysis shall be documented in the Stress Analysis Report.

6.1.2 A comprehensive pipe stress analysis shall be conducted for the high-pressure gas system and documented in the Stress Analysis Report.

Clarification: Even though a comprehensive pipe stress analysis is only required for the High-pressure gas system, all the other piping systems that apply to this Specification have to follow the requirements listed in this Specification, including piping that falls under the simplified pipe stress analysis criteria. The requirement for a comprehensive piping stress analysis on the other piping systems should be based on competent engineering judgment.

6.1.3 The boundary conditions and all assumptions shall be based on competent engineering judgment and listed in the Stress Analysis Report.

6.1.4 If applicable to the analysis, all boundary conditions obtained from project documents such as the Design Basis Memorandum (DBM), and all assumptions shall be referenced.

6.1.5 The piping stress model shall include the meter station piping, pipeline tie-ins and assemblies, and adjoining pipeline up to the virtual anchor (VA) length.

6.1.6 Location factors separating pipelines, tie-ins, and meter station shall be clearly indicated in the drawings and the Stress Analysis Report.

6.1.7 The Company's Project Manager, with competent authenticated engineering justification, shall provide the following information:

- maximum operating temperature
- maximum design temperature
- minimum underground temperature
- minimum aboveground temperature
- maximum design pressure
- maximum licensed operating pressure

6.2 Pipe Analysis Software

6.2.1 Either of the following software products should be used for pipe stress modeling and analysis:

- AutoPIPE by Bentley Inc. (preferred)
- Caesar II by COADE Inc.

6.2.2 Alternative software for conducting stress analysis on meter stations should be code-compliant and approved by the Company's Stress Engineering personnel, unless the Project Manager accepts responsibility for the use of alternative software.

6.2.3 Specialty programs (FEA) should only be used in conjunction with programs that have code-checked integration, unless code-checking has been considered using another method.

6.2.4 All software files and models (original and convertible to AutoPIPE) should be supplied and attached to the hard copy of the report.

6.2.5 The Bourdon Effects or Calculated Pressure Extension for both translational and rotational displacements shall be accounted for in the analysis.

6.2.6 The Calculated Pressure Extension shall be accounted for in the analysis.

6.3 Restraint

6.3.1 Both aboveground and belowground piping shall be modeled and evaluated assuming unrestrained loading conditions, and that the pipe is able to move.

Clarification: The partial restraint from soil or pipe supports can be assumed to be unable to fully prevent movement of the piping.

6.4 Load Cases

Note: As part of the stress analysis and the Company's long-term commitment to performance, loading cases shall comply with both code compliance cases and the Company's loading requirements.

6.4.1 The operational case, cold case, and occasional case shall be analyzed.

6.4.2 The minimum and maximum temperatures defined in the Design Basis Memorandum (DBM) shall be used in the analysis.

6.5 Operational Case

6.5.1 The operational case shall include the following:

- effects of pressure (maximum operating pressure)
- operating temperatures (maximum operational temperature)
- pipe weight (including insulation, content, backfill overburden, underground pipe settlement and other externally imposed displacement such as nozzle displacements

6.6 Cold Case

6.6.1 The cold case shall be analyzed to determine whether the pipe stresses and loads on the pipe supports are within the allowable limits for cold case.

6.6.2 The cold case shall include the following:

- effects of pressure (maximum design pressure for all piping)
- operating temperatures (minimum temperature for all piping)
- pipe weight (including insulation, content, backfill overburden, underground pipe settlement and other externally imposed displacement such as nozzle displacements)

6.7 Occasional Case

6.7.1 The occasional case shall be analyzed to determine whether the piping system complies with the regulatory code for occasional stresses.

6.7.2 The occasional case shall include the operational case combined with the effect of external forces (wind and seismic).

6.7.3 Each occasional case shall be analyzed independently.

6.7.4 Wind - the building code (Canada, United States and Mexico) shall be used for the area where the meter station is to be located to determine the maximum wind speed (km/h for Canada and Mexico and mph for the United States) for a 50-year occurrence.

6.7.5 Wind - The predominant wind direction shall be used for the analysis.

6.7.6 Static Seismic (Earthquake) - The seismic loading shall be considered along with the operational case.

Clarification: A seismic event is most likely to occur while the piping system is in operation.

6.7.7 Static Seismic (Earthquake) - The seismic load shall be reported as Peak Gravity Acceleration (PGA), multiple in gravity acceleration equivalent (multiple of g-force).

Clarification: The seismic loading combined with the static load cases need to be combined to ensure code compliance.

6.8 Load Combinations and Allowable Stress Requirements

6.8.1 Bending stress from pressure elongation shall be accounted for in the analysis.

Clarification: The default AutoPIPE settings for CSA Z662 - *Oil and Gas Pipeline Systems*, tensile 2, may be missing the bending stress from pressure elongation. A custom code case may need to be added manually to ensure that the bending stress from pressure elongation is accounted for.

6.8.2 The code combinations for *American Society of Mechanical Engineers (ASME) B31.8 - Gas Transmission and Distribution Piping Systems* and *CSA Z662 - Oil and Gas Pipeline Systems,* provided in Table 6-1, shall be analyzed depending on facility location.

6.8.3 A bi-axial combined stress case shall be included in the analysis, in addition to any code requirements, considering all operational caseloads.

6.8.4 The bi-axial combined stress may be calculated using a Tresca or a Von Mises stress criterion.

6.8.5 Additional combinations should be added based on operating modes of piping systems. The code combinations provided are the base cases only.

6.8.6 All load case combinations shall be analyzed as presented in order of load sequence.

6.8.7 Local stresses caused by structural discontinuities and sites of local loadings combined with load case combinations should not exceed 0.9 of the Specified Minimum Yield Strength (SMYS).

Clarification: Often, local stresses are disregarded because the stresses are localized in influence, may be self-limiting, or relieved by local deformation. This includes stresses in branch connections caused by pressure or external loads, or stresses at structural discontinuities, as well as the contact stress caused by pipe supports. The codes do not fully address the maximum allowable value for local stresses or excessive stresses. However, not exceeding 0.9 of the Specified Minimum Yield Strength (SMYS) ensures that the design is defendable to the code.

Table 6-1: Code Combinations for ASME B31.8 and CSA Z662

Case No.	Load Combination	Stress Type	Description	Allowable
1	Max P	Hoop	Hoop stress ASME B31.8 Para. 841.1.1 CSA Z662, Clause 4.3.5.1	 SMYS x E x F x T SMYS x F x L x T
2	GR + Max P	Longitudinal	Stress due to Sustained Loads ASME B31.8 Para 833.6 CSA Z662, Clause 4.8.5	 0.75 x SMYS x T SMYS x F x L x T
3	Amb T to Max T	Longitudinal	Thermal stress range from restraint temp to the maximum temperature ASME B31.8, Para. 833.8 CSA Z662, Clause 4.8.4	 f[1.25(Sc+Sh)-SL] 0.72 x SMYS x T
4	Max Range (Max T to Min T)	Longitudinal	Thermal stress range from the minimum temp to the maximum temperature (refer to all combinations) ASME B31.8, Para. 833.8 CSA Z662, Clause 4.8.4	 f[1.25(Sc+Sh)-SL] 0.72 x SMYS x T
5	GR + Max P + U2	Longitudinal	Stress due to Sustained Load and Occasional (i.e.: Load earthquake, wind, and blowdown forces.) ASME B31.8, Para. 833.8 CSA Z662, Clause 4.8.5	 0.75 x SMYS x T SMYS x F x L x T
6	GR + Max P + Max T	Combined, Bi-axial	Combined Stress Without Bending Stress ASME B31.8, Para. 833.3 (a) CSA Z662, Clause 4.7.1	0.90 x SMYS x T 0.90 x SMYS x T
7	GR + Max P + Max T	Combined, Bi-axial	Combined Stress ASME B31.8, Para. 833.4 (c) CSA Z662, Clause 4.7.2.1	0.90 x SMYS x T 1.0 x SMYS x T
8	GR + Max P + Max T + U1	Combined, Bi-axial	Combined Stress with Soil Settlement ASME B31.8, Para. 833.4 (c) CSA Z662, Clause 4.7.2.1	 0.90 x SMYS x T 1.0 x SMYS x T

Case No.	Load Combination	Stress Type	Description	Allowable
9	GR + Max P + Max T + U1 + U2	Combined, Bi-axial	Combined Stress with Soil Settlement and Occasional Load ASME B31.8, Para. 833.4 (c) CSA Z662, Clause 4.7.2.1	0.90 x SMYS x T 1.0 x SMYS x T

Table 6-2: Descriptions

Load	Description
GR	Weight of piping system due to gravity and soil overburden
Max P	Maximum operating pressure.
Max T	Maximum operating temperature. (may vary based on section of piping)
Min T	Minimum operating temperature. (may vary based on section of piping)
Amb T	Ambient temperature.
U1	Soil settlement
U2	Occasional loads (e.g., earthquake, wind, blowdown forces, etc.)
E	Weld joint factor
T	Temperature derating factor
F	Design factor
L	Location (Z662 only)
f	Fatigue factor
Sc	Defined in the codes
Sh	Defined in the codes
Sl	Defined in the codes
SMYS	Specified minimum yield strength

6.9 Content Weight

6.9.1 The content weight (i.e., density) shall be applied to all piping analyzed.

Clarification: Some models have assumed the contents of the pipe to be weightless; this weight (i.e., density) content may not affect the results of the model. However, this approach cannot be defended.

6.9.2 The content weight (i.e., density) shall be the value calculated at the maximum pressure.

6.10 Thermal Analysis Conditions

6.10.1 The maximum design temperature shall be defined as the highest temperature for the station (the maximum licensed operating temperature) as provided in the Design Basis Memorandum (DBM).

6.10.2 The minimum temperature for the underground portions of the pipe stress model shall be the lowest expected metal temperature at the time of restraint.

6.10.3 The minimum temperature for the underground portions of the pipe stress model should be as follows, unless an alternative definable minimum underground temperature has been provided:

- For Canada and the northern part of the United States, the minimum temperature for the underground portions of a piping system should be assumed -10°C (14°F), unless otherwise specified.
- For the southern part of the United States and Mexico, the minimum temperature for the underground portions of a piping system should be assumed +5°C (41°F), unless otherwise specified.

6.10.4 The minimum temperature for the aboveground portions of the pipe stress model shall be the lowest expected temperature for the region during operation.

6.10.5 The minimum temperature for the aboveground portions of the pipe stress model should be as follows, unless an alternative definable minimum temperature has been provided tracking environmental data for the past 50 years:

- For Canada and the northern part of the United States, the minimum temperature for the aboveground portions of a piping system should be assumed -45°C (-49°F), unless otherwise specified.
- For the southern part of the United States and Mexico, the minimum temperature for the aboveground portions of a piping system should be assumed -20°C (-4°F), unless otherwise specified.

6.10.6 The ambient/installation temperature shall be the lowest expected temperature for the region during construction:

- For buried piping the ambient/installation temperature should be the lowest expected ground consolidation temperature at the time of construction.
- For above ground piping the ambient/installation temperature should be the lowest expected air temperature at the time of construction.

6.10.7 The maximum temperature differential shall be the difference between the maximum operational temperature and the minimum temperature or the ambient/installation temperature, whichever is lower.

6.10.8 The maximum temperature differential shall be considered for the expansion case.

6.11 Soil Modelling Requirements

6.11.1 If a facility or project-specific soil analysis report is not available, all soil assumptions shall be based on competent engineering judgment and supplied in the Stress Analysis Report.

6.11.2 The soil constraints implemented in the pipe stress model shall be determined at the pipe depth of cover, soil properties and soil types typical for the area of construction.

6.11.3 Soil spring properties should be estimated using the methodology outlined in Appendix B of the *Guideline for the Design of Buried Steel Pipe – July 2001*, American Lifelines Alliance, unless justification can be given for the consideration of an alternative.

6.11.4 Soil spring properties determined from the stress analysis program, such as the *Underground Pipe Modeler*, *Buried Pipe Modeler*, or any other methodology used to determine the soil stiffness through use of the program, should be checked and evaluated by hand calculations, unless a consideration can be given why conducting hand calculations as a validation is not required.

Clarification: A plug-and-play type of approach to determining soil properties for underground piping analysis leads to over and underestimating the influences onto the piping. Without a good understanding of the *black box* the soil calculating programs cannot be used.

6.11.5 Overburden wedge weight shall be added as a uniform distributed load (to the computer model) to all underground piping, both new and existing.

6.11.6 The overburden compaction multiplier, defined in CAESAR II, shall not be used for stress analysis unless the following is provided:

- approval from the Company's Stress Engineering personnel
- the derivation of the overburden compaction multiplier
- a complete understanding of the interaction and influence the multiplier has on soil spring properties

6.12 Soil Settlement Modeling

6.12.1 Soil settlement displacement shall be applied to all new piping and newly excavated sections of existing underground piping.

6.12.2 Soil settlement displacement should not be applied to existing sections of piping that have not been excavated.

Clarification: The existing pipe is assumed to have already settled prior to being tied into the new piping.

6.12.3 A soil settlement displacement or void space under piping of 25.4 mm (1.0 in.) or greater should be applied to new and existing excavated sections of piping where there is a low probability of over-excavation and where compaction is being called for in the design.

Clarification 1: The amount of soil settlement is dependent on the soil properties, soil type and site conditions. The minimum settlement assumes that good construction practices have been followed and that strict compaction requirements have been achieved using competent compactable unfrozen backfill.

Clarification 2: Settlement of underground piping can occur even with the best procedures in place for the following reasons:

- Geotechnical analysis has determined that the elastic rebound from the removal of the soil to the ditch bottom causes an upward displacement of around 12.7 mm (0.5 in.), which causes settlement after backfilling and reconsolidation.
- Over-excavation of the ditch bottom to ensure proper pipe alignment and tie-ins will settle as the soil reconsolidates.
- Practical difficulties in achieving compaction under large diameter pipe, simply as a function of their size, can result in void space under large diameter pipe.

6.12.4 A soil settlement displacement greater than 25.4 mm (1.0 in.) should be applied to new and excavated existing sections of piping where there is a high probability of over-excavation, such as areas where pipe transitions between belowground and aboveground.

Clarification: Pipe settlement greater than 25.4 mm (1.0 in.) is a real possibility if the pipe is over-excavated. The amount of settlement is a site-specific issue and should be based on competent engineering judgment and supplied in the Stress Report.

Note: The individual(s) conducting the pipe stress analysis have a responsibility to understand the construction process, through discussions with the project team, to determine the locations where there is a low and/or high probability of over-excavation.

6.13 Pipe Support Design Loads

6.13.1 Support loads shall include, but are not limited to the following:

- soil settlement
- pipe weight
- overburden
- vehicle loads
- inspection tools
- blowdown pressure
- temperature
- hydro
- wind

6.13.2 The pipe support loads provided by the piping stress analysis should be unfactored for the Civil Designer.

Clarification: The appropriate factoring is to be determined by the Civil Designer based on the applicable design codes.

6.13.3 The maximum pipe support load should be divided into two load types: dead (gravity) load and live (all other loads).

6.13.4 Blowdown loads should be unfactored.

6.13.5 Soil overburden loads should be included as a dead load.

6.13.6 To validate the support type for both aboveground and belowground, localized membrane stresses shall be determined for unfactored support loads.

Clarification: With the pipe resting on a support, high localized stresses in both the circumferential and longitudinal directions are generated within the pipe wall adjacent to the edge of the support.

6.13.7 Localized pipe wall membrane stresses should be determined using Roark's Formulas.

Clarification: Allowing for a more detailed correlation of the localized membrane stresses through detailed Finite Element Analysis (FEA) is time consuming and resource intensive when an analytical solution is just as effective.

Recommendation: Determine the maximum allowable support load for each support type, pipe size, wall thickness and grade at the initial stage of the project to ensure that the loads are not exceeded, and tabulate the allowable loads in the report.

6.13.8 Alternative methods for determining localized membrane stresses require pre-approval from the Company's stress engineering personnel or the Project Engineer and Project Manager.

6.13.9 Localized pipe wall membrane stresses shall be combined with the circumferential and longitudinal stresses to ensure that the allowable stress requirements are not exceeded.

Clarification: Determination of localized pipe wall membrane stresses combined with the circumferential and longitudinal stresses is a very important calculation and will be a focus in the *Initial Procedural Document*.

6.13.10 Beneficial effects gained from restraining soil that reduces localized membrane stresses should be ignored in the calculation.

6.13.11 The stiffnesses of the supports in the vertical, lateral and axial directions used in the piping stress analysis should be estimated based on competent engineering judgment.

Recommendation: Predetermine the approximate stiffness of a support type or structural assembly, within an order of magnitude, by a structural engineer. The point of determining the support stiffness is to have an idea of the structural rigidity of the support and to attain realistic loads.

6.14 Pipe Support Coefficient of Friction

6.14.1 The coefficient of friction should not be lower than the following minimum requirements, unless consideration has been given to the long-term functionality of the coefficient of friction, and determining the coefficient of friction experientially under multiple environmental conditions as per Table 6-3.

Table 6-3: Pipe Support Coefficient of Friction

Conditions	Minimum Coefficient of Friction
UHMW-to-UHMW (Ultra-High Molecular Weight polyethylene)	0.2
UHMW-to-Steel (steel is coated or painted pipe)	0.2
Neoprene-to-Steel (steel is coated or painted pipe)	0.4
Steel-to-Steel (steel is coated or painted support to steel of coated or painted pipe)	0.4 to 0.8 (check both cases as a minimum)
Concrete-to-Steel (concrete support to steel of coated or painted pipe)	0.4 to 0.8 (check both cases as a minimum)

Recommendation: The use of steel-to-steel (i.e., support-to-pipe) and concrete-to-steel (i.e., support-to-pipe) contact is not recommended. Interfacial corrosion and adhesion would make the coefficient of friction unpredictable and the long-term environmentally exposed interface would be unreliable.

6.14.2 If steel-to-steel (i.e., support-to-pipe) and concrete-to-steel (i.e., support-to-pipe) surface contact are to be used, two extreme cases should be investigated: 1) the lower friction case of 0.4 to 0.8 and 2) a higher friction case greater than 1.2.

Clarification: If there is a chance that the support could seize and due to rust, corrosion, or surface roughness conducting the analysis over the range will help determine the risk to the piping system.

6.14.3 The coefficient of friction for steel-to-steel (i.e., support-to-pipe) and concrete-to-steel (i.e., support-to-pipe) contact should be tested under environmental conditions and surface roughness expected over the life of the support to ensure that the analysis is defendable.

6.15 Allowable Pipe Support Displacement

6.15.1 The Company's Engineering personnel should be contacted for guidance, if the piping displacements determined from the initial layout and analysis are outside of the recommended displacements.

6.15.2 The maximum piping displacement at the location of aboveground pipe support should not exceed the absolute value of the following, unless consideration has been given to the long-term functionality of the support, regulatory compliance concerns, maintenance and operational concerns as per Table 6-4.

Table 6-4: Allowable Pipe Support Displacement at Aboveground Pipe Support

Direction	Maximum Pipe Displacement
Axial direction	63.5 mm (2.50 in.)
Lateral direction (sliding support)	25.4 mm (1.00 in.)
Lateral direction (non-sliding support)	6.0 mm (0.25 in.)
Vertical upward direction	4.0 mm (0.15 in.)
Vertical upward direction (blowdowns and valves)	3.0 mm (0.12 in.)
Vertical upward direction (first support from riser)	12.0 mm (0.47 in.)
Vertical downward direction	6.0 mm (0.25 in.)

Clarification: The first support aboveground, after the riser, may receive vertical lift due to thermal displacement. Care needs to be taken to ensure that piping is not over stressed and the support is functional for the operational range.

6.15.3 The maximum piping displacement at the location of belowground pipe support should not exceed the absolute value of the following, unless consideration has been given to the long-term functionality of the support, and soil ratcheting as per Table 6-5.

Table 6-5: Allowable Pipe Support Displacement at Belowground Pipe Support

Direction	Maximum Pipe Displacement
Axial direction	63.5 mm (2.50 in.)
Lateral direction (sliding support)	25.4 mm (1.00 in.)
Lateral direction (non-sliding support)	6.0 mm (0.25 in.)
Vertical upward direction	4.0 mm (0.15 in.)
Vertical downward direction	6.0 mm (0.25 in.)

6.15.4 Facilities to pipeline tie-in should be located where the displacement is at a minimum or where additional piping flexibility has been added to minimize displacement, unless consideration has been given to the long-term functionality of the support and the increased engineering vigilance on the structural requirements.

6.15.5 Blowdowns should be located where the thermal movement from the attached piping is at a minimum, unless consideration has been given to the long-term functionality of the support and the increased engineering vigilance on the structural requirements and increased costs.

Clarification: The blowdown needs to be seated on the pipe supports to ensure that the thrust loads during blowdown operation are taken by the supports.

6.16 Fittings

6.16.1 Fittings should be modeled as pipe, unless the stresses of the fittings exceed the allowable code stresses.

6.16.2 The wall thickness of fittings NPS 16 and greater may be increased up to 1.4 times the nominal pipe wall thickness for tees and 1.2 times the nominal pipe wall thickness for elbows, once approved by the Project Manager.

6.16.3 Elbow and tee fittings smaller than NPS 16 shall be modeled with the same wall thickness as the adjoining pipe.

6.16.4 The assumption of increasing the wall thickness of the fitting in the analysis shall be documented in the Stress Analysis Report and validated through the procurement process.

6.16.5 The assumption of increasing the wall thickness of the fitting in the analysis shall be approved by the Company's Stress and Mechanical Engineering personnel or the Project Engineer and Project Manager.

6.16.6 For each type of fitting used, the Stress Intensity Factors (SIFs) shall be documented along with the assumption for that fitting.

6.16.7 The SIFs provided in *CSA Z662 - Oil and Gas Pipeline Systems, Gas Transmission and Distribution Piping Systems* or *ASME B31.8 - Gas Transmission and Distribution Piping Systems* shall be used unless approved by the Company's Stress and Mechanical Engineering personnel or the Project Engineer and Project Manager.

6.17 Flange Analysis

6.17.1 Flange Analysis shall be conducted for all large diameter piping.

6.17.2 *ASME Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 1, Rules for Construction of Pressure Vessels - Appendix 2, Rules for Bolted Flange Connections with Ring Type Gaskets* shall be used for conducting the flange analysis.

6.17.3 The calculated or determined externally induced forces and moments shall be included in all flange analyses conducted.

Clarification: The flange analysis is a very important calculation and will be a focus in the *Initial Procedural Document*.

6.17.4 Flanges not meeting the flange analysis criteria of *ASME BPVC-VIII, Division 1, Appendix 2* after reasonable efforts have been made to mitigate by relocation, piping re-design and/or rating increase, may consider *ASME BPVC-VIII, Division 2, Section 4.16 - Design Rules for Flanged Joints,* including the calculated or determined externally induced forces and moments.

6.17.5 Written approval from the Company's Stress Engineering personnel, Mechanical Engineering personnel, Project Engineer and Project Manager shall be obtained before using *ASME BPVC-VIII, Division 2, Section 4.16* as a flange analysis criteria.

6.17.6 Alternative methodologies for conducting flange analysis should not be considered.

Note: The direct design requirement to conduct a flange analysis may not be specifically listed in the piping design code as a design requirement. However, inspecting, identifying, monitoring, tracking, preventing and eliminating fugitive emissions or leaks are regulatory and legal requirements, and are essential to ensuring the Company's commitment to the environment. In part, flange connections have been identified as a source for fugitive emissions that require continuous annually monitoring and, in certain jurisdictions, prompt repair or mitigation. Therefore, increased engineering vigilance to ensure that the flange joint meets the flange analysis requirements for the location reduces the probability of the flange joint being an integrity concern.

6.18 Discontinuity Stresses

6.18.1 Protection shall be provided against membrane stresses, ratcheting and fatigue failure for discontinuity conditions using sound engineering judgment and practices.

6.19 Mitigation for Stress Issues

6.19.1 Expansion medium may be used for underground piping to mitigate stress concentrations issues, soil ratcheting, and displacement concerns.

6.19.2 Expansion medium (i.e., Ethafoam® 220) may be modeled by any of the following methods:

- applying a stiffness coefficient for the expansion medium
- removing the soil stiffness coefficient, leaving a void for the area where expansion medium is planned

6.19.3 Flanges that do not meet the flange leakage criteria should be relocated and reevaluated.

6.19.4 Flanges not meeting the flange analysis criteria after being relocated and reevaluated may be upgraded or removed with the approval of the Company's Stress Engineering personnel, Mechanical Engineering personnel, Project Engineer and the Project Manager.

6.19.5 If the pipe displacement at the location of a pipe support is greater than allowed the following methods may be applied:

- the pipe support relocated and reevaluated
- flexibility added to the piping
- adjusting and modifying the pipe support

6.20 Evaluation of Existing Piping Impacted by New Piping or Piping Modifications

6.20.1 A model of the original un-modified piping should be developed.

6.20.2 The stress on existing piping shall be checked to meet the code of compliance.

6.20.3 Any areas on existing piping not meeting current analysis or current code of compliance shall be documented.

6.20.4 The Company's Project Manager and Pipe Stress Analyst shall ensure that the modifications do not cause detrimental stress increases to the existing piping.

6.20.5 If the original piping exceeds the current code of compliance, the original piping shall be evaluated against the code of compliance at the time of design.

6.20.6 A structural pipe support evaluation shall be conducted if there is a significant increase in the support loads.

6.20.7 The equipment nozzles shall be evaluated against allowable load.

7 DOCUMENTATION AND REPORT REQUIREMENTS

7.1 Analyst and Experience Requirements

7.1.1 Pipe stress analysts require a bachelor's degree in mechanical or civil engineering, followed by a minimum of five years of project training in a piping department responsible for design, while under the supervision of senior/or principal pipe stress engineers.

7.1.2 Pipe stress analysts with less formal education shall have 10-15 years of practice and supervision to be responsible for the design (i.e., pipe stress analysis).

7.1.3 The names of the individual(s) conducting the pipe stress analysis shall be listed in the *Initial Procedural Document* and the reports.

7.1.4 The experience of the competent individual(s) with demonstrated understanding and experience in the application of pipe stress analysis shall be listed.

7.2 Initial Procedural Requirements

7.2.1 Competency of the individual(s) conducting the stress analysis and the individual(s) checking their work shall be demonstrated and documented at the initial stage of the project.

7.2.2 The Project Engineer or Project Manager should provide a list of Company-approved support types at the kick-off meeting.

7.2.3 An *Initial Procedural Document* shall be provided to the Company during vendor qualification and updated whenever a stress analysis is being conducted as part of the project.

7.2.4 A written *Initial Procedural Document* describing the method for conducting the stress analysis piping shall be completed prior to engineering analysis being conducted.

7.2.5 The written *Initial Procedural Document* shall include the following:

- general information – listing (purpose, method, assumptions, supplemental calculations, references, analysis theories, etc.)
- quality control procedure which describes the process of reviewing, checking and authenticating the stress analysis report, analysis and calculations

Clarification: A common problem is the lack of communication and understanding of the analysis to be conducted and the procedural approach that will be followed during the engineering analysis. This includes the documentation required to ensure the analysis was conducted methodically, and reviewed, checked and authenticated by competent individual(s) having experience to demonstrate understanding in the application of stress analysis.

7.2.6 The written *Initial Procedural Document* for this Specification shall also include, at a minimum, the methodology for calculating the following:

- pressure and temperature assumptions
- pipe weight with the added operational contents weight
- list of piping systems to be modeled
- method for applying overburden loads
- soil spring properties and methodology
- extent of the piping to be modeled, including existing piping
- soil settlement modeling methodology
- load cases to be run in the model
- outline of any supplemental calculations or modeling being done that is unique to the project
- list of the pipe support types that are going to be used for the project aboveground and belowground with corresponding support stiffness
- method for determining localized membrane stresses

7.2.7 The written *Initial Procedural Document* procedure shall be reviewed, checked, authenticated and delivered to the Project Manager for review by the Company's Engineering personnel.

7.2.8 The written *Initial Procedural Document* procedure and approach should be reviewed to ensure it meets the Company's minimum requirements and is based on solid engineering judgment before engineering analysis is conducted.

7.2.9 Any changes and comments made by the Company to the written procedures and approach should be implemented before engineering analysis is conducted.

7.3 Stress Analysis Report Requirements

7.3.1 A Stress Analysis Report shall be provided if a comprehensive piping stress analysis is being conducted as part of a project within a meter station yard.

7.3.2 A comprehensive piping stress analysis report shall include, but not be limited to, the following:

1. General Information

- brief description of the project
- software used for creating the model
- piping code used
- maximum allowable pipe stress
- equipment loads
- sketch or drawing with dimensions used to create the model

2. Pipe Support Table
    - support name (tag#)
    - point number
    - location (aboveground/belowground)
    - depth of cover
    - pipe sizes wall thickness
    - material grade support type
    - support description
    - isolation medium between pipe and support
    - gap up, left, and right
    - support stiffness
    - loading direction
    - maximum loads (lateral, vertical, axial)
    - dead load
    - soil load
    - live load
    - pipe displacements (lateral, vertical, axial)
3. Assumed Operating Conditions
    - load cases
    - maximum pipe temperature
    - ambient temperature
    - soil temperature
    - minimum pipe temperature pressures
4. Assumed External Loads
    - soil overburden
    - soil properties
    - depths of soil cover
    - estimated soil spring properties

- soil settlement (areas of model affected)
- vehicle loads (areas of model affected)
- sustained forces (weight of pipe, components, contents (hydro) insulations cover, wind loading)

5. Images

- stress magnitude spectrum in piping
- location of nodes in stress model
- locations of supports and support types
- the distance of pipe support from reference points such as centreline of elbows, tees, etc.
- locations of installed stress mitigation methods (e.g., Ethafoam® 220)

6. Areas of Concern

- table of pipe stress ratios/values at nodes
- table of support loads referencing a labelled picture for support location
- changes made to piping arrangement to reduce stresses, if any
- any stress mitigation methods and estimated stiffness (e.g., Ethafoam® 220) including a list of the physical properties and test methods
- recommendations/discussion.

7. Calculations

- wall thickness calculation or reference
- SIF (show calculation if different than code SIFs)
- soil overburden load calculations
- Virtual Anchor (VA) length calculations
- soil spring calculations
- membrane stress calculations for pipe sizes, wall thicknesses, grades and support types
- blowdowns and pressure relief valves force calculations
- flanges leakage calculations
- vehicle loading calculations

8. Procedures

- written compaction plan or procedure

9. Discussion

- issues and limitations of the designed system including: explanations, examples, sketches, and illustrations

10. Analyst and Experience

- The names of the individual(s) conducting the pipe stress analysis shall be listed.
- The experience of the competent individual(s) with demonstrated understanding and experience in the application of pipe stress analysis shall be listed.

7.3.3 The report shall be issued to the Project Manager.

7.3.4 The draft report should be issued before drawings are issued for review (IFR).

7.3.5 The final report shall be issued before drawings are issued for construction (IFC).

8 VARIANCES

Any deviation shall follow the TransCanada Management of Change (MOC) Variance Procedure. External vendors must contact the TransCanada Project Engineer for variance approval.

9 ROLES AND RESPONSIBILITIES

Table 9-1 below outlines the roles and responsibilities required for the use of this Specification.

Table 9-1: Roles and Responsibilities

Role	Responsibilities
Civil Designer	The Civil Designer is responsible for ensuring: • completion of the civil design • calculation of support stiffness • provision of calculations to the Pipe Stress Analyst • incorporation of the support loads (as determined by the stress analysis) into the design of the pipe supports
Checker, Civil Designer	The Checker is responsible for ensuring that the Civil Designer(s) has: • completed the civil design • calculated the support stiffness • provided calculations to the Pipe Stress Analyst • incorporated the support loads (as determined by the stress analysis) into the design of the pipe supports

Role	Responsibilities
Mechanical Designer	The Mechanical Designer is responsible for ensuring: • completion of the mechanical design • accommodation for the required support types • the piping layout and adequate bracing • all drawings are reviewed to ensure that the edge of the support is a minimum of one diameter (1d) away from any pipe girth weld and that the other requirements of this specification are met • provision of adequate space for the pipe support on the ISO sketches • provision of adequate clearances between supports and weld joints in the spool drawings.
Checker, Mechanical Designer	The Checker is responsible for ensuring that the Mechanical Designer has: • completed the mechanical design • accommodated for the required support types • verified the piping layout and ensured adequate bracing • ensured all drawings are reviewed to confirm that the edge of the support is a minimum of one diameter (1d) away from any pipe girth weld, and that the other requirements of this specification are met • provided adequate space for the pipe support on the ISO sketches • provided adequate clearances between supports and weld joints in the spool drawings
Pipe Stress Analyst	The Pipe Stress Analyst is responsible for ensuring: • integration between the mechanical and civil design/function gap • completion of the stress analysis • long-term operation through the range of operating conditions • reduction of mechanical and civil complexity, pipe stress (membrane) and nozzle loads • augmentation of piping system flexibility • compliance with all applicable codes, specifications and any manufacturer's requirements • errors, issues, concerns, bugs or other software problems used for conducting the stress analysis are addressed and actions have been taken to ensure code compliance • validation of the all software used for the piping stress analysis

Role	Responsibilities
Checker, Pipe Stress Analyst	The Checker is responsible for ensuring that the Pipe Stress Analyst has: • bridged the gap between the mechanical and civil design/function • completed the stress analysis • ensured long-term operation through the range of operating conditions • reduced mechanical and civil complexity, pipe stress (membrane) and nozzle loads • augmented piping system flexibility • complied with all applicable codes, specifications and any manufacturer's requirements • addressed errors, issues, concerns, bugs or other problems encountered with the software used for conducting the stress analysis and taken the necessary action to ensure code compliance • validated all software used for the piping stress analysis
Project Engineer (PE)	The Project Engineer (PE) is responsible for ensuring: • adherence to this specification • competency of the analyst has been demonstrated in the experience section of the stress analysis report • any and all considerations have been documented • documentation of any areas where the Project Engineer (PE) has assumed responsibility • documentation and inclusion of competency in project records
Project Manager (PM)	The Project Manager (PM) is responsible for ensuring: • adherence to this specification • competency of the analyst has been demonstrated in the experience section of the stress analysis report • any and all considerations have been documented • documentation of any areas where the Project Manager (PM) has assumed responsible • documentation and inclusion of competency in the project records

10 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are detailed below in Table 10-1, Table 10-2, and Table 10-3. Use the latest document revision, unless otherwise approved by TransCanada.

Table 10-1: Regulatory References

Organization/Document No.	Title
NEB OPR SOR/99-294	*National Energy Board Onshore Pipeline Regulations (NEB OPR)*
CFR Title 49 Part 192	*Transportation of Natural And Other Gas By Pipeline: Minimum Federal Safety Standards*
NORMA Oficial Mexicana NOM-007-SECRE-2010	*Transporte de gas natural and any amendment or errata issued by CRE*

Table 10-2: External Industry References

Organization/Document No.	Title
ALA	*ALA (2002) Guideline for the Design of Buried Steel Pipe – July 2001, American Lifelines Alliance.*
API 650	*American Petroleum Institute - Welded Tanks for Oil Storage*
API 1102	*American Petroleum Institute - Steel Pipelines Crossing Railroads and Highways*
ASME/ANSI B1.1	*American National Standards Institute - Screw Thread Standards*
ASME B31.8	*American Society of Mechanical Engineers - Gas Transmission and Distribution Piping Systems*
ASME BPVC-VIII	*American Society of Mechanical Engineers - Boiler and Pressure Vessel Code, Section VIII, Division 1, Rules for Construction of Pressure Vessels*
CEPA	*Canadian Energy Pipeline Association - Surface Loading Calculator*
CSA Z662	*Construction Safety Association - Oil and Gas Pipeline Systems*
DNV	*Structural Analysis of Piping Systems*, DNV–RP-D101, DNV October 2008.
Energy Institute Publication	*Guidelines for the Avoidance of Vibration Induced Fatigue Failure in Process Pipework*, January 2008.
Kormann, P. and Zhou, J.	*Support Spacing of Buried and Above-Ground Piping, Second International Conference, Advances in Underground Pipeline Engineering.* American Society of Civil Engineers, Bellevue, Washington, June 25-28, 1995.
Young, W.C.	*Roark's Formulas for Stress and Strain*, 6th ed., McGraw-Hill Book Co., New York, 1989.

Table 10-3: Internal References

Document No.	Title
EDMS No. 000006566	*TES-DV26-2906 Tubing and Fittings*
EDMS No. 000006457	*TES-DV31-2333 Excavating, Backfilling, and Grading*
EDMS No. 004430969	*TES-DV31-2333-US Excavating, Backfilling and Grading*
EDMS No. 007913244	*TES-ME-STRHO-GL Pipe Stress Engineering Analysis and Design of Hot Tap Branch Connections (CDN-US-MEX)*

11 DOCUMENT HISTORY

Rev.		
02	**Description**	**Effective Date**
	3.11 was updated to ensure the supports spacing for aboveground piping includes all pipe diameters	2017-Dec-01
	Rationale Statement	**Responsible Engineer**
	n/a	Michael Martens
	Impact Assessment Summary	**Document Owner**
	n/a	Michael Martens
Rev.		
01	**Description**	**Effective Date**
	New document.	2017-Apr-10
	Rationale Statement	**Responsible Engineer**
	This document was developed in order to address the following requirements: • Consolidation of specifications. The following specifications/documents have been combined into this document: – *TES-STRS-METER, Pipe Stress Analysis for Meter Stations (CDN-US-MEX)* – *TES-STRS-GBRANCH, Gas Pipelines Small Diameter Piping, Branch Connections and Attachments (CDN-US-MEX)* (TES-STRS-GBRANCH was in draft at the time of the consolidation)	Michael Martens
	Impact Assessment Summary	**Document Owner**
		Michael Martens

12 APPROVALS

APPROVALS		
Originator: Michael Martens, M.Sc., P. Eng. Mechanical & Civil Engineering	Michael Martens Signature	Nov. 14. 2017 Date
Reviewer: Les Tan, P. Eng. Pipeline Engineering	Signature	Nov. 16, 2017 Date
Reviewer: Steven Foo, P. Eng. Measurement Engineering	Signature	Nov. 14, 2017 Date
Responsible Engineer: Michael Martens, M. Sc., P. Eng. Mechanical & Civil Engineering	Michael Martens Signature Nov. 22. 2017 Date	PROFESSIONAL ENGINEER MICHAEL G. MARTENS ALBERTA APEGA Permit to Practice P7100
Management Endorsement: Seema Makwana, Manager Mechanical & Civil Engineering	Signature	Nov 23 2017 Date

APPROVALS

Originator and Document Contact: Ryan M[c]Kay, P. Eng. Corrosion Engineer Pipe Integrity, Corrosion Prevention	Signature	Feb 19, 2014 Date
Reviewer: John Chin US Pipeline Operations Regulatory Compliance	Signature	Date
Reviewer: Charles Bucy Corrosion Specialist Pipe Integrity, Corrosion Prevention	Charles S. Bucy Signature	Feb. 19, 2014 Date
Reviewer: Matt Cetiner, P. Eng Senior Engineer Pipe Integrity, Program Strategy	Signature	Feb 19, 2014 Date
Design Discipline Checker / Responsible Engineer / Approver / Engineer-in-Charge: Chad Khattar, P. Eng. Senior Engineer Pipe Integrity, Corrosion Prevention	Signature April 7, 2014 Date	PROFESSIONAL ENGINEER CHAD J. KHATTAR ALBERTA APEGA Permit to Practice P7100
Management Endorsement: James Card, BSEE Manager Pipe Integrity, Corrosion Prevention	James L Card Signature	Feb 19, 2014 Date

SUMMARY

This specification outlines the criteria for cathodic protection on the Company's natural gas and hazardous liquid buried pipelines in Canada, Mexico, and the US.

APPROVALS

Originator and Document Contact: Ryan McKay, P. Eng. Corrosion Engineer Pipe Integrity, Corrosion Prevention	Signature	Date
Reviewer: John Chin US Pipeline Operations Regulatory Compliance	John S Chin Signature	3/7/14 Date
Reviewer: Charles Bucy Corrosion Specialist Pipe Integrity, Corrosion Prevention	Signature	Date
Reviewer: Matt Cetiner, P. Eng Senior Engineer Pipe Integrity, Program Strategy	Signature	Date
Design Discipline Checker / Responsible Engineer / Approver / Engineer-in-Charge: Chad Khattar, P. Eng. Senior Engineer Pipe Integrity, Corrosion Prevention	Signature Date	APEGA Permit to Practice P7100
Management Endorsement: James Card, BSEE Manager Pipe Integrity, Corrosion Prevention	Signature	Date

SUMMARY

This specification outlines the criteria for cathodic protection on the Company's natural gas and hazardous liquid buried pipelines in Canada, Mexico, and the US.

DOCUMENT HISTORY

Rev. No.		
05	**Description**	**Effective Date**
	Addition of criteria for aboveground storage tanks bottoms. Addition of criteria for pipelines in Mexico.	2014-Feb-12
	Rationale Statement	**Responsible Engineer**
	Compliance to industry and regulatory standards. Compliance to regulatory standards in Mexico.	Chad Khattar
	Impact Assessment Summary	**Team Owner**
	Impact assessment is covered in the associated TOPs.	Pipe Integrity, Corrosion Prevention
04	**Description**	**Effective Date**
	Editorial and format changes throughout the document Addition of US piping	2012-Dec-21
	Rationale Statement	**Responsible Engineer**
		Brad Woloschuk
	Impact Assessment Summary	**Team Owner**
	This specification applies to all the Company's natural gas and hazardous liquid pipeline systems in Canada and the US	Pipe Integrity, Corrosion Prevention
03	**Description**	**Effective Date**
	Revision to criteria for pipe in MLVs 2-43, the 400 Line, & Foothills Pipelines. Clarification of criteria for all lines.	2004-Mar-25
	Rationale Statement	**Responsible Engineer**
		Garry Norton
	Impact Assessment Summary	**Team Owner**
		Engineering and Operation Services (E & OS)
02	**Description**	**Effective Date**
	Revision to criteria for pipe in MLVs 2-43, the 400 Line, & Foothills Pipelines. Clarification of criteria for all lines.	2003-Apr-01
	Rationale Statement	**Responsible Engineer**
		Wayne Corcoran
	Impact Assessment Summary	**Team Owner**
		Engineering and Operation Services (E & OS)
01	**Description**	**Effective Date**
	Revisions to criteria and editorial changes mostly associated with reference drawing updates.	2001-Dec-15
	Rationale Statement	**Responsible Engineer**
		Corey Goulet
	Impact Assessment Summary	**Team Owner**
		Engineering and Operation Services (E & OS)

<table>
<tr><td rowspan="6">00</td><td>Description</td><td>Effective Date</td></tr>
<tr><td>New document.</td><td>2000-Sep-01</td></tr>
<tr><td>Rationale Statement</td><td>Responsible Engineer</td></tr>
<tr><td>This document was developed in order to address the following requirements:
• To meet regulatory criteria</td><td>Larry Saisho</td></tr>
<tr><td>Impact Assessment Summary</td><td>Team Owner</td></tr>
<tr><td></td><td>Engineering and Operation Services (E & OS)- Engineering Analysis, Standards & Technology</td></tr>
</table>

BRIEF DESCRIPTION OF CHANGE

REGULATORY	
Section	**Description of Change**
	N/A
INDUSTRY STANDARDS	
Section	**Description of Change**
	N/A
GENERAL	
Section	**Description of Change**
	Editorial and format changes throughout the document
	Addition of Mexico piping

Table of Contents

List of Tables

DEFINITIONS

Term	Definition
AC	alternating current
cathodic protection (CP)	A technique used to reduce the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.
CFR	Code of Federal Regulations
CGA	Canadian Gas Association
Company	TransCanada
corrosion potential	The mixed potential of a freely corroding metal surface for a reference cell in contact with the same electrolyte (also referred to as native, static or initial potential).
CP	cathodic protection
CSA	Canadian Standards Association
DC	direct current
electrolyte	A chemical substance containing ions that migrate in an electric field. Water or soils are common electrolytes for pipelines.
environment	The conditions that the structure and/or cathodic protection system operates, which might include atmospheric and/or underground conditions, stress, temperature, soil, liquids and solids.
Foothills Pipelines (FHPL)	Foothills Pipelines and facilities are located within British Columbia, Alberta and Saskatchewan.
HVAC	high-voltage AC power line
instant-off potential	The measured pipe-to-electrolyte potential taken immediately after all influencing cathodic protection systems have been de-energized. This is also referred to as the polarized potential.
IR drop	The voltage across a resistance in accordance with Ohm's Law.
mA	milliampere (10-3 amperes)
MIC	microbially-influenced corrosion
mV	millivolt (10-3 volts)
NACE	NACE International (formerly National Association of Corrosion Engineers)
NOM	Norma Oficial Mexicana
off potential	See *instant-off potential*.
on potential	The measured pipe-to-electrolyte potential with cathodic protection current applied. The components of an on potential include the native potential, polarization and IR drop.
permanent reference electrode	A half-cell, usually $Cu\text{-}CuSO_4$ that is designed to last many years in a permanently buried position.
pipe-to-electrolyte (pipe-to-soil or pipe-to-seawater) potential	The potential difference between the pipe metallic surface and the electrolyte (soil) that is measured to a reference electrode in contact with the electrolyte (soil).
polarization	The deviation from the corrosion potential of an electrode resulting from the flow of current between the electrode and the electrolyte.

Term	Definition
polarized potential	The potential across the structure or electrolyte interface to a reference electrode that is the sum of the corrosion potential and the cathodic polarization. See also *instant-off potential*.
reference electrode	A portable or permanently installed half-cell, usually Cu-$CuSO_4$, that is used to take coupon or pipe-to-electrolyte potentials from grade, inside the coupon test station's reference tube or from a permanently installed buried location.
voltage	An electromotive force or a difference in electrode potentials (volts).

1 PURPOSE

This specification outlines the criteria for cathodic protection on buried pipelines, and is intended for use by knowledgeable, trained, experienced and operator qualified (US requirement) personnel. These criteria have been developed through research, laboratory and field-testing, and an analysis of empirical data.

2 SCOPE

This specification applies to all the Company's natural gas and hazardous liquid pipeline systems in Canada, Mexico and the US.

3 REFERENCES

3.1 Regulations Codes and Standards

The jurisdictional regulations and legal requirements that apply to this specification are:

- 49 Code of Federal Regulations (CFR):
  - 192, Subpart I, Appendix D
  - 195, Subpart H
- Canadian Standards Association (CSA) Z662 (2011) *Oil and Gas Pipeline Systems*
- Norma Oficial Mexicana (NOM) NOM-007-SECRE-2010 *Natural Gas Transportation – Appendix I*

3.2 Industry Publications and References

The industry publications and references that apply to this specification are:

- Canadian Gas Association (CGA) OCC-1-2005 – Recommended Practice – Control of External Corrosion on Buried or Submerged Metallic Piping System
- CSA Standard 22.3 No. 6, Principles and Practices of Electrical Coordination Between Pipeline and Electric Supply Lines
- NACE International:
  - SP0169-2007 – *Control of External Corrosion on Underground or Submerged Metallic Piping Systems*
  - TM0497-2002 – *Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems*

3.3 Internal References

The Company procedures, guidelines, reports and documents that apply to this specification are:

- *Memo – Justification for 900 mV Criterion and Discontinuation of the Interrupted Surveys* (EDMS No. 007759192)
- *Operations and Maintenance (O&M) Manual U.S. Hazardous Liquids Pipelines* (EDMS No. 005713585)
- *Operations and Maintenance (O&M) Manual U.S. Natural Gas Pipelines* (EDMS No. 005404490)

- *Operator Qualification Program* (EDMS No. 004504739)
- Report – *Optimization of Survey Frequency – Statistical Analysis of On-Potential Criterion* (EDMS No. 007759183)
- Report – *Pulse Generator/Wave Form Analyzer Study of Cathodic Protection Pipe to Soil Potentials of Below Ground Steel Pipelines in Alberta* (EDMS No. 007759215)
- TES-CP-IV *Mitigation of Induced AC Voltage Effects (CDN-US)* (EDMS No. 003671383)
- TOP *Cathodic Protection Single Point Survey Inspection* (EDMS No. 003671419)

4 CRITERIA APPLICATION BY REGION AND PIPELINE

4.1 General

The Company adheres to:

- Canadian Standards Association (CSA) Z662 (2011) *Oil and Gas Pipeline Systems*
- recommended practice CGA OCC-1-2005 Appendix B.2.1
- 49 CFR 192, Subpart I,
- 49 CFR 195, Subpart H criteria
- NOM-007-SECRE-2010 Appendix I

The cathodic protection criteria for steel structures are as follows:

- A negative polarized (instant-off) potential of at least 850 mV.
- A negative polarized (on) potential of at least 850 mV accounting for the voltage (IR) drops.
- A minimum of 100 mV of cathodic polarization between the structure and a reference electrode contacting the electrolyte, as measured by the formation or decay of polarization.

Unless otherwise specified, all structure-to-electrolyte potentials are measured for a saturated copper–copper sulphate reference electrode placed in contact with the soil directly above the buried pipe or, when applicable, adjacent to a pipe riser.

4.1.1 Special Considerations

Sometimes conditions exist where cathodic protection is ineffective, or only partially effective. These conditions might include such things as elevated temperatures, under disbonded coating, shielding and soil conditions. Deviation from the specification might be warranted, providing an engineering analysis demonstrates that the objectives inherent in this specification have been achieved.

Where regulations permit, other CP criteria may be used in site-specific locations where corrosion control can be demonstrated through an engineering analysis and supported by Pipe Integrity.

Microbially Influenced Corrosion

The criteria for areas with microbially influenced corrosion (MIC) shall be to achieve a more negative polarized (instant-off) potential of -950 mV relative to a saturated copper–copper sulphate electrode. If this criterion is not met, tests must be done to determine if at least 150 mV polarization is achieved. Note: For Mexico the 150 mV polarization criterion does not apply.

Aboveground Storage Tanks

The 100 mv “shift” criteria listed in Section 4.1 may be more suitable for aboveground storage tank bottoms. Achieving -850 mV “OFF” may be impractical and could cause electro-osmotic drying under the tank resulting in irreversible damage to the CP system and CP environment.

4.2 Alberta

This section applies to the pipelines in Alberta, including Foothills Pipelines.

The criterion for the operation and maintenance of cathodic protection shall be to achieve an “on” potential more negative than -950 mV, as per the Report – *Pulse Generator/Wave Form Analyzer Study of Cathodic Protection Pipe to Soil Potentials of Below Ground Steel Pipelines in Alberta*, except as noted in the following clauses.

Where an on potential of -950 mV cannot be met, the criteria outlined in Section 4.1 applies.

4.2.1 Single Non-Looped Extruded Polyethylene Coated Pipelines

The criterion shall be to achieve an on potential more negative than -1000 mV, relative to a saturated copper–copper sulphate electrode on the test lead furthest from the groundbed. The test lead furthest from the groundbed shall be monitored annually. The remaining test leads shall be monitored at least every five years, and shall achieve an on potential more negative than -950 mV. For more information, refer to TOP *Cathodic Protection Single Point Survey Inspection*.

4.2.2 Peace River Mainline

Due to known areas of MIC on a tape-coated pipeline in this area, the criteria shall be to achieve an on potential more negative than -1000 mV. Where instant-off potentials are practical, a more negative polarized (instant-off) potential of -950 mV relative to a saturated copper–copper sulphate electrode shall be the criterion. If this criterion is not met, tests must be done to determine if at least 150 mV polarization is achieved in MIC areas.

4.2.3 Western Alberta System

For the Western Alberta System (WAS) extension north of Valve 1024, the criteria shall be to achieve an on potential between -1000 mV and -1200 mV with reference to a saturated copper–copper sulphate electrode, if an instant-off potential or depolarization test result cannot be obtained.

4.3 Mainline

4.3.1 Saskatchewan and Manitoba

The criterion applies to the Mainline pipeline from Mainline Valve 1 (MLV 1) to Mainline Valve 43 (MLV 43) inclusive, and the 400 lines.

The criterion for the operation and maintenance of cathodic protection shall be to achieve an on potential more negative than -900 mV, as per the Memo – *Justification for 900 mV Criterion and Discontinuation of the Interrupted Surveys* and theReport – *Optimization of Survey Frequency – Statistical Analysis of On-Potential Criterion.*

Where an on potential of -900 mV cannot be met, the criteria outlined in Section 4.1 applies.

4.3.2 Foothills Saskatchewan

Zone 9 Mainline and Loops

The criterion for the operation and maintenance of cathodic protection shall be to achieve an on potential more negative than -950 mV.

Where an on potential of -950 mV cannot be met, the criteria outlined in Section 4.1 applies.

Zone 9 Compressor Stations, Sales Meter and Foreign Crossings

The criterion for the operation and maintenance of cathodic protection shall be to achieve an instant-off potential more negative than -850 mV, relative to a saturated copper–copper sulphate electrode.

4.4 Mexico

This section applies to the pipelines in Mexico. In addition to the criteria set forth in Section 4.1, the maximum voltage should not exceed -2.5 volts in powered conditions in relation to a reference electrode, or -1.1 volts in a condition of instant shutdown.

4.5 Off-shore Facilities

The cathodic protection criteria for off-shore facilities are as follows:

- A negative polarized (instant-off) potential of at least 800 mV referenced to a silver-silver chloride reference cell.
- A negative polarized (on) potential of at least 800 mV accounting for the voltage (IR) drops referenced to a silver-silver chloride reference cell..

4.6 A minimum of 100 mV of cathodic polarization between the structure and a reference electrode contacting the electrolyte, as measured by the formation or decay of polarization.Alternating Current Voltages

For pipelines near an high-voltage alternating current (HVAC) powerline where personnel might be in contact with the pipeline and associated facilities, the maximum safe voltage, for steady-state conditions on a pipeline is 15 volts AC (see CSA 22.3 No.6, and CFR 192 and CFR 195). Refer to TES-CP-IV *Mitigation of Induced AC Voltage Effects (CDN-US)* for further information.

4.7 Summary

The above criteria for all regions of the Company's natural gas and hazardous liquid pipeline systems in Canada, Mexico and the US are summarized in Table 4-1. Note: all of the general criteria detailed in Section 4.1 apply, but are not detailed in the table below.

Table 4-1: Summary of the Company's Cathodic Protection Criteria

Location	Criterion	Survey Requirement
British Columbia (BC), Canadian Montana Lateral, and WAS from Burton Creek Lateral to Alberta–BC Border (including FHPL)		
All lines, stations.	Minimum -850 mV "off"	Perform "on/off" survey.

Location	Criterion	Survey Requirement
Alberta		
Peace River mainline and areas of known MIC.	Minimum –1000 mV "on"	Perform "on" survey.
WAS Extension North of Valve 1024.	Between –1000 mV and –1200 mV "on"	Perform "on" survey.
In Wildrose Alberta, small diameter non-looped extruded polyethylene lines.	Minimum –1000 mV "on" (annual) Minimum -950 mV "on" (5 year full survey)	Perform "on" survey. Refer to Section 4.2.1 (single-point survey required).
All other lines (including FHPL), stations.	Minimum –950 mV "on"	Perform "on" survey.
Aboveground storage tanks	Minimum –850 mV "off"	Perform "on/off" survey.
Mainline: MLV 1 to MLV 43 and the 400 Lines		
All lines and sales meter stations (SMSs), except MLV 16.	Minimum –900 mV "on"	Perform "on" survey. At foreign crossings, interrupt closest upstream and downstream rectifiers.
Foothills Saskatchewan mainline and loops.	Minimum -950 mV "on"	Perform "on" survey. At foreign crossings, interrupt closest upstream and downstream rectifiers.
MLV 16 (including SMSs).	Minimum –900 mV "on"	Perform "on/off" survey.
Stations and foreign crossings (including Foothills).	Minimum –850 mV "off"	Perform partial "on/off" survey. Only interrupt rectifiers within the station yard.
Mainline: MLV 43 & Eastward		
All lines, MLVs, SMSs and stations.	Minimum –850 mV "off"	Perform "on/off" survey.
United States: ANR, North Baja, Bison, Great Lakes, GTN, Keystone, Northern Border, and Tuscarora		
All lines, MLVs, SMSs, aboveground storage tanks and stations.	Minimum –850 mV "off"	Perform "on/off" survey.
Mexico: Guadalajara and Tamazunchale		
All lines, MLVs, SMSs, aboveground storage tanks and stations.	Minimum –850 mV "off"	Perform "on/off" survey.

5 QUALITY MANAGEMENT

5.1 Specification Deviations

When there is a request to vary from the specification as documented, an approved Management of Change is required. All deviations are to be reviewed and approved by the specification owner before the variance can proceed on the deliverable, data or report. In no case will a variance be granted that causes an applicable regulatory requirement to be violated.

5.2 Noncomformance Management

All nonconformances to this specification will be reviewed by the Company and dispositioned by the vendor.

APPROVALS

Originator: Ryan McKay, P. Eng Corrosion Engineer Pipe Integrity, Corrosion Prevention	Signature	Jan 22, 2013 Date
Reviewer: Chad Khattar, P. Eng Senior Engineer Pipe Integrity, Corrosion Prevention	Signature	Jan 23, 2013 Date
Reviewer: Brent McKinnon Program Management U.S. Pipeline Maintenance Projects	Signature	Jan 24 2013 Date
Responsible Engineer/Approver/ Engineer-in-charge/Document Contact: Brad Woloschuk, P. Eng Senior Engineer Pipe Integrity, Corrosion Prevention	Signature FEBRUARY 01, 2013 Date	PROFESSIONAL ENGINEER BRADLEY J. WOLOSCHUK 2013-02-01 APEGA Permit to Practice P7100
Accountable Manager: James Card, BSEE Manager Pipe Integrity, Corrosion Prevention	Signature	1/28/13 Date

SUMMARY

This specification establishes the requirements for cathodic protection materials for the installation of cathodic protection facilities for Company gas and hazardous liquid pipeline systems in Canada and the United States.

BRIEF DESCRIPTION OF CHANGE

REGULATORY

- N/A

GENERAL

- Editorial and format changes throughout the document.

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List of Tables

DEFINITIONS

Terms	
ACSR	aluminum conductor steel-reinforced cable
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
CEC	Canadian Electrical Code
CSA	Canadian Standards Association
ECTFE	ethylene chlorotrifluoroethylene
HMW-MDPE	high molecular weight high density polyethylene
HMWPE	high molecular weight polyethylene
IEC	International Electrotechnical Commission
NACE	NACE International
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
RMU	remote monitoring unit
The Company	TransCanada PipeLines
XLPE	cross-linked polyethylene

Tools and Applications	
Incident and Issue Tracking (IIT)	An electronic database tool used to report incidents and issues involving employees, contractors and third parties.
FileNet-EDMS	The Company's web-based electronic document management system.

1 PURPOSE

This specification establishes the requirements for cathodic protection materials for the installation of cathodic protection facilities for the Company's buried pipeline systems in Canada and the United States.

This specification shall be used:

- By Company employees and all prime and Subcontractors employed by the Company
- In all activities related to cathodic protection, including design, construction, operations and maintenance

Materials supplied shall meet all requirements of this specification and any additional requirements on the applicable request for quotation, purchase order and applicable Company standard drawings.

Before a material is added to the Approved Material List, it shall be reviewed and approved by the Company's Cathodic Protection Engineering personnel.

2 SCOPE

This specification applies to materials for cathodic protection for the Company's gas and hazardous liquid pipeline systems in Canada and the United States.

3 REFERENCES

3.1 Regulations, Codes and Standards

The jurisdictional regulations and legal requirements that apply to this procedure are:

- 49 Code of Federal Regulations (CFR):
  - 192, Subpart I
  - 195, Subpart H
- Canadian Standards Association (CSA):
  - Z662-11 *Oil and Gas Pipeline Systems*
  - C22.1 Canadian Electrical Code (CEC), *Part I, Safety Standard for Electrical Installations (Section 80)*
  - C22.2 No. 107.1, *General Use of Power Supplies*
  - C22.2 No. 131, *Type TECK 90 Cable*
  - C22.2 No. 75, *Thermoplastic-Insulated Wires and Cables (Tri-National standard, with UL 83 and NMX-J-010-ANCE*, 2008
  - Special Publication SPE-1000-94, *Model Code for the Field Evaluation of Electrical Equipment*
- National Fire Protection Association (NFPA) 70 National Electrical Code (NEC)

3.2 Industry Publications and References

The industry publications and references that apply to this procedure are:

- NACE International:
  - SP0169-2007, *Control of External Corrosion on Underground or Submerged Metallic Piping Systems*
  - SP0572-2007, *Design, Installation, Operations, and Maintenance of Impressed Current Deep Anode Beds*
- American Society for Testing and Materials (ASTM) International:
  - G97, *Standard Test Method for the Laboratory Evaluation of Magnesium Sacrificial Anode Test Specimens for Underground Applications*
  - B265, *Standard Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate*
  - B418, *Standard Specification for Cast and Wrought Galvanic Zinc Anodes*
  - B843, *Standard Specification for Magnesium Alloy Anodes for Cathodic Protection*
  - A518, *Standard Specification for Corrosion-Resistant High-Silicon Iron Castings*
  - D1248, *Standard Specification for Polyethylene Plastics Molding and Extrusion Materials For Wire and Cable*
  - D2000, *Standard Classification System for Rubber Products in Automotive Applications*
  - B3, *Standard Specification for Soft or Annealed Copper Wire*
  - B8, *Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft*
  - D293, *Standard Test Method for the Sieve Analysis of Coke*
  - D709, *Standard Specification for Laminated Thermosetting Materials*
  - D3172, *Standard Practice for Proximate Analysis of Coal and Coke*
  - D3173, *Standard Test Method for Moisture in the Analysis Sample of Coal and Coke*
  - D3174, *Standard Test Method for Ash in the Analysis Sample of Coal and Coke from Coal*
  - D3178, *Standard Test Method for Ultimate Analysis for Hydrogen Content*
  - D5142, *Standard Test Methods for Proximate Analysis of the Analysis Sample of Coal and Coke by Instrumental Procedures*
  - D4239, *Standard Test Methods for Sulphur in the Analysis Sample of Coal and Coke Using High Temperature Tube Furnace Combustion Methods*
  - D4749, *Standard Test Method for Performing the Sieve Analysis of Coal and Designating Coal Size*
- American Society of Mechanical Engineers (ASME) B16.21, *Nonmetallic Flat Gaskets for Pipe Flanges*
- International Electrotechnical Commission (IEC):
  - 60060-1, *High-voltage test techniques, Part 1: General definitions and test requirements*
  - 60060-2, *High voltage test techniques, Part 2: Measuring systems*
  - 60228, *Conductors of Insulated Cables*

- National Electrical Manufacturers Association (NEMA):
  - WC70/ICEA S-96-658, *Thermoplastic Insulated Wire & Cable for Transmission & Distribution*
  - Standard Publication No. MR 20-1958 (reaffirmed by NEMA 1971) – *Semiconductors, Rectifiers, Cathodic Protection Units*
  - Standard Publication No. MR 250-1979 (including Rev No. 1 December 1980), *Enclosures for Electrical Equipment (1000 Volts Maximum)*

3.3 Internal References

The Company procedures, guidelines, reports and documents that apply to this specification are:

- *Operations and Maintenance (O&M) Manual U.S. Natural Gas Pipelines* (EDMS No. 005404490)
- *Operations and Maintenance (O&M) Manual U.S. Hazardous Liquids Pipelines* (EDMS No. 005713585)
- *Operator Qualification Program* (EDMS No. 004504739)
- TEP-INT-MOC *Pipe Integrity Management of Change Procedure* (EDMS No. 006425143)

4 ROLES, RESPONSIBILITIES AND QUALIFICATIONS

4.1 Manufacturer's Responsibilities

4.1.1 Requirements for All Materials

Following are material requirements:

- The manufacturer shall be on the Company's cathodic protection Approved Materials List (see APPENDIX A) for the production of cathodic protection materials.
- At the request of the Company Representative, cathodic protection material may be retained by the Company for evaluation to ensure the material conforms to this specification.
- The Company shall have the right to review the manufacturer's work at any time.
- The manufacturer shall supply to the Company at the time of quotation any exceptions or alternatives to this specification.

4.1.2 Preproduction Provisions

For isolation sets, the manufacturer shall submit to the Company the following:

- For each sleeve size, the inside diameter (ID), outside diameter (OD), thickness and length (all in millimetres or inches), material type, and the dielectric strength (volts per 1 mm or inch).
- For each washer type and size, the ID, OD and thickness (all in millimetres or inches), material type, and if applicable, dielectric strength (volts per 1 mm or 1 inch).

For rectifiers, the manufacturer shall submit to the Company:

- A certification that the rectifier meets the requirements of this specification
- A nationally recognized testing laboratories (NRTL) approval certification
- A circuit diagram and dimensions of the enclosure

For:

- Thermoelectric generators (TEG), the manufacturer shall certify that the TEG(s) meet the requirements of this specification, and provide a diagram showing the components of the TEG(s) and dimensions of the enclosure(s).
- Calcined coke, the manufacturer shall submit a datasheet detailing the chemistry and other requirements in Section 5.3.
- Cables, the manufacturer shall certify that the cable meets the requirements of the CEC or the NEC (as applicable), ASTM D 1248 or NACE Standard SP0572 and this specification.
- Each monolithic isolator, the manufacturer shall submit to the Company the fabrication drawing and the production schedule.
- Remote monitoring equipment and rectifiers, the manufacturer shall supply laminated electrical schematic drawings with each rectifier, and copies shall be submitted to the Company.

4.2 Company Responsibilities

The Company representative shall obtain all QA/QC documents for materials to be installed, in accordance with the project description.

5 CATHODIC PROTECTION MATERIALS – REQUIREMENTS

5.1 Anodes

5.1.1 High-Potential Magnesium Anodes

Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass and dimensions are as follows:

- The anode shall conform to ASTM B843, Grade M1C.
- The anode shall have a minimum efficiency of 43%, when tested in accordance with ASTM G97.
- The mass of the anode, anode dimensions and package dimensions shall be as specified on the purchase order.
- A galvanized steel core shall be cast at least 75% of the full anode length.

Lead Wire

See Section 5.2.2, Magnesium Anodes or Zinc Anodes.

Backfill

See Section 5.3.5.

Markings

The anode type, mass (kg/lbs) and Company specification and revision date shall be legibly marked on each anode package with a weather-resistant marker or a label (e.g., High Potential Magnesium, 15 lbs, TES-CP-MS [Cdn-US], 2012/10/01).

Shipping

Shipping specifications are as follows:

- The backfill package shall consist of a cotton bag or wettable (e.g., no wax or plastic coated) cardboard tube with the dimensions as specified on the purchase order.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.1.2 Zinc Ribbon

Chemical Composition, Mass and Dimensions

Chemical composition, mass and dimension specifications are as follows:

- The chemical composition of zinc ribbon shall conform to ASTM B418, Type II. The anode dimensions shall be as specified on the purchase order or Company standard drawings.
- The anode shall be manufactured by extrusion with a continuous centered 1/8" galvanized steel core.

Lead Wire

Not applicable.

Backfill

Not Applicable.

Markings

The following shall be legibly marked with a weather-resistant marker on a tag attached to the reel (or other device anode is wrapped around):

- manufacturer
- anode model
- ribbon type
- cross section (X millimetres [inches] x Y millimetres [inches])
- length (metres or feet)
- Company specification and revision date

For example, "manufacturer", aaa, zinc ribbon, 12 mm x 15 mm, 500m, TES-CP-MS (Cdn-US), 2012/10/01.

Shipping

Shipping specifications are as follows:

- The ribbon shall be packaged in a manner to allow for ease of shipping.
- The zinc ribbon shall be prepared for shipment and storage in such a manner that it will not be exposed to weather or water, as directed by the supplier.

5.1.3 Zinc Grounding Cells

Chemical Composition, Mass and Dimensions

The chemical composition for the zinc shall conform to ASTM B418, Type II. The anode dimensions shall be as specified on the purchase order or Company standard drawings.

Lead Wire

See Section 5.2.2, Magnesium Anodes or Zinc Anodes.

Backfill

See Section 5.3.5.

Markings

The anode type, mass (kilograms or pounds) and the Company specification and revision date shall be legibly marked on each anode package with a weather-resistant marker or a label (e.g., Zinc Grounding cell, 7.7 kg, TES-CP-MS [Cdn-US], 2012/10/01).

5.1.4 Silicon-Chromium Cast Iron Anodes

Chemical Composition, Mass and Dimensions

The following clauses shall apply to both tubular and stick anodes castings:

- The anode shall be chill cast or equal, from an alloy conforming to ASTM A518 GR3.
- Each anode shall be supplied free from casting defects, porosity, voids and fissures. The anode surface shall be free from adhering foundry sand or mould release agents.
- The anode mass and anode dimensions shall be as specified on the purchase order or Company standard drawings.
- All anode manufacturers shall be approved by the Company.

Lead Wire

See Section 5.2.2, Tubular Anodes.

Backfill

See Sections 5.3.1 to 5.3.4.

Markings

The following shall be legibly marked with a weather-resistant marker on a tag attached to the anode:

- manufacturer
- anode model
- anode type
- anode mass (kilograms or pounds)
- anode OD (millimetres or inches)
- length (millimetres or inches)
- Company specification
- revision date

For example, "manufacturer", aaa, stick, 20 kg, 50 mm, 1520 mm, TES-CP-MS (Cdn-US), 2012/10/01.

Shipping

Shipping specifications are as follows:

- Anodes shall be packaged in a manner to avoid breaking during shipment.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water, as directed by the supplier.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.1.5 Continuous Polymer Anodes

Chemical Composition, Mass and Dimensions

Specifications for chemical compositions, mass and dimensions are as follows:

- Continuous polymer anodes shall be constructed as stranded American Wire Gauge (AWG) 6 annealed copper conductors with a conductive polymer jacket (rather than an insulating polymer jacket).
- The conductive polymer jacket shall provide a moisture-proof barrier to protect the copper cable.
- The conductive polymer jacket shall be capable of continuously discharging a current of 50 mA per linear metre (15 mA per linear foot) of anode material for a minimum of twenty years.

Lead Wire

See Section 5.2.3.

Backfill

See Section 5.3.

Markings

The following shall be legibly marked with a weather-resistant marker on a tag attached to the anode:

- manufacturer
- anode model
- polymer type
- length (metres or feet)
- Company specification
- revision date

For example, "manufacturer", aaa, carbon impregnated polyethylene, 500m, TES-CP-MS (Cdn-US), 2012/10/01).

Shipping

Shipping specifications are as follows:

- As specified on the purchase order or Company standard drawings, continuous polymer anodes may be supplied bare (by itself) or prepackaged in a 38 mm (1½ inch) diameter flexible mesh tube.
- Prepackaged conductive polymer anodes shall contain a high-grade coke backfill conforming to Section 5.3. The conductive polymer anode shall be centered within the flexible mesh tube.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water, as directed by the supplier.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.1.6 Canister Anodes

Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass and dimensions are as follows:

- Only tubular anodes shall be placed in canisters. Anodes shall meet the requirements of Section 5.1.4 before assembly.
- The canisters shall be manufactured as follows:
    - spiral corrugated perforated galvanized steel – 28 gauge minimum
    - diameter – 225 to 235 mm (8 inches) minimum
    - length – anode length + 600 mm (2 feet)
    - plywood end caps – 16 mm (¾ inch) minimum thickness

Assembly

High silicon chromium anode assemblies shall be canistered as follows:

- With the bottom end cap in place, the anode shall be centered in the can and filled with coke, such that the anode has 200 mm (8 inches) of coke beyond each anode end.
- Calcined petroleum coke, as per Section 5.3, shall be mechanically compacted around the anode.
- An inner plywood cap shall be secured to the can immediately above the compacted calcined petroleum coke.
- A steel bolted eyelet shall be attached to the top inner plywood cap, and the lead wire shall exit through a close fitting hole to the side of center.
- The wire shall be coiled and placed on the inner cap.
- A top end cap, with access to the coiled wire, shall be attached to protect the coiled wire during shipping.

Refer to Company standard drawings.

Shipping

Shipping specifications are as follows:

- All canned anodes shall be securely attached to a pallet in such a manner to avoid damage to the anodes or canisters.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water, as directed by the supplier.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.1.7 Graphite Anodes

Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass and dimensions are as follows:

- The chemical composition for the graphite shall be GR060CP grade or equal.
- The graphite shall be treated with wax or resin, as specified on the purchase order.
- Center connections shall be tested to verify the connection falls below 0.004 ohms (4 milliohms).

Lead wire

See Section 5.2.2.

Backfill

See Section 5.3.

Shipping

Shipping specifications are as follows:

- Anodes shall be packaged in a manner to avoid breaking during shipment.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water.
- The anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.1.8 Mixed Metal Oxide Anodes – MMO Anodes

Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass, and dimensions are as follows:

- The chemical composition of titanium shall conform to ASTM B265.
- The anode rating per foot and length is as specified on the purchase order.

Lead wire

See Section 5.2.2.

Backfill

See Section 5.3.

Shipping

Shipping specifications are as follows:

- Anodes shall be packaged in a manner to avoid damage during shipment.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water.
- The anode wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.2 Cable

5.2.1 General

General specifications for cable are as follows:

- All cable shall be rated for use from -40°C to 60°C, or -40°F to 140°F.
- Cables shall have an underground rating.
- All cables shall conform to ASTM B3 and ASTM B8 or IEC 60228.
- All cables shall be rated to handle 600 V direct current.
- Unless specified, the cable size, cable length and cable colour shall be as indicated on the purchase order or Company standard drawings.
- The outer insulation layer shall be marked to include the manufacturer, conductor size and number of strands (e.g., "manufacturer," AWG 4, 7/S).

5.2.2 Anode Lead Wire

Magnesium Anodes or Zinc Anodes

Specifications for magnesium anodes or zinc anodes are as follows:

- The anode lead wire shall be a continuous seven stranded, AWG 10 or larger (unless specified on the purchase order) annealed copper conductor, minimum 3 metres (10 feet) long. The insulation shall be blue for magnesium anodes and white for zinc, unless specified on the purchase order, to be consistent with site specific installations. The insulation shall be RWU90 cross-linked polyethylene (XLPE), or direct burial high molecular weight polyethylene (HMWPE).
- Lead wires shall be attached to the galvanized steel core by silver solder, and the connection shall be made moisture-proof by encapsulating the connection with an electrical sealing compound. The lead wire connection shall withstand a steady load pull of 200 kg (440 lbs) without separation from the anode.
- For zinc grounding cells, the lead wire shall be a continuous seven stranded, AWG 2 or larger annealed copper conductor, minimum 3 metres (10 feet) long. The insulation shall be white for zinc anodes. The insulation shall be RWU90 XLPE, or direct burial HMWPE. The wire shall be compression connected to the anode core and sealed with an electrical sealing compound.
- If magnesium anodes are to be used with solar panels, the cables shall meet the requirements of an impressed current system.

Tubular Anodes

Specifications for tubular anodes are as follows:

- For deep-well anode leads, see Deep Anode Lead Cable in Section 5.2.3.
- Unless otherwise specified, anode leads shall be AWG 8.
- The anode lead wire shall be a continuous conductor of AWG 8 with a seven-stranded copper conductor. The insulation shall be black, and shall consist of at least 2.78 mm (0.1 inch) of high molecular weight, medium density polyethylene that conforms to ASTM D 1248, Type II, Class C, Category 4, Grade J4E9.
- The use of lead (Pb) anchors for cable connections is not permissible.
- Attachment of the lead wire to the anode shall be made by a permanent compression connection. The lead wire connection shall be centered inside the anode.
- The anode lead wire shall be visually inspected before attaching the anchoring assembly, to ensure that none of the copper strands have been scored or scratched. Before applying the compression crimp connector, the copper strands of the lead wire shall be manually twisted into a compact spiral to facilitate even distribution of stress to each of the strands.
- The lead wire MDPE or HMWPE jacket surface shall be roughened for 50 mm (2 inches) anode end to improve adhesion to the sealant.

- The lead wire center connection to the anode shall be sealed using ArmorThane STS-200 Side A and Side B cured polyurethane, or approved equivalent. The sealant thicknesses shall be a minimum of 150 mm (6 inches) both above and below the center connection. The depths (millimetre or inches) of top and bottom epoxy seals shall be measured by probing and recorded directly on the outside of all anodes with a permanent marker. In addition, date and distributor name shall be marked with a permanent marker on the anode.
- The seller to the Company shall perform non-destructive random checks of sealant levels, as quality assurance that sealant levels marked on the outside of the anodes are correct. Records of quality assurance checks completed shall be sent to the Company before shipping. If any non-conformances are indicated, all other anodes having the same assembly date and manufacturer shall be inspected and repaired as necessary to meet this specification.
- The lead wire connection to the anchoring assembly shall be destructively tested before and at the end of each production day, to ensure compression equipment is operating satisfactorily. In addition, each anode shall be manually (i.e., by hand) pull tested by the technician after the mechanical connection to the anode is completed. Pull tests shall not be performed after sealant application.
- All anode leads shall be tested to ensure electrical continuity to the anode after sealant has cured and before shipping.
- Anode leads shall be attached in accordance with anode manufacturer's recommended mechanical procedures. The anode manufacturer shall provide a lead wire installation procedure to the anode supplier and Company. In case of conflict between this specification and manufacturer's recommended procedures, this specification shall apply.
- Attachment of the anode lead wire shall only be performed by previously approved distributors.

5.2.3 Other Cable

Negative Cable

Cables shall have stranded annealed copper wires. Insulation shall conform to NEMA WC70/ICEA S-96-658, have a minimum thickness of 2.78 mm (0.1 inch) and shall be high molecular weight, medium density polyethylene that conforms to either:

- ASTM D 1248, Type II, Class D, Category 4, Grade J4E9,
- ASTM D 1248, Type I, Class C, Category 5, Grade E5 and J1, or
- ASTM D 1248, Type I, Class A, Category 5, Grade E4 and E5

Minimum thickness of the HMWPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and a minimum of 18 strands for cable sizes larger than AWG 2.

Positive Cable

Cables shall have stranded annealed copper wires. Insulation shall conform to NEMA WC70/ICEA S-96-658, have a minimum thickness of 2.78 mm (0.1 inch) and shall be high molecular weight, medium density polyethylene that conforms to either:

- ASTM D 1248, Type II, Class C, Category 4, Grade J4E9,
- ASTM D 1248, Type I, Class C, Category 5, Grade E5 and J1, or
- ASTM D 1248, Type I, Class A, Category 5, Grade E4 and E5

The minimum thickness of the HMWPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and a minimum of 18 strands for cable sizes larger than AWG 2.

Cables shall have stranded annealed copper wires. Insulation shall conform to NEMA WC70/ICEA S-96-658, and shall be high molecular weight, medium density polyethylene that conforms to:

- ASTM D 1248 Type II, Class D, Category 4, Grade D6
- ASTM D 1248, Type I, Class C, Category 5, Grade E5
- J1 or ASTM D 1248, Type I, Class A, Category 5, Grade E4 and E5

The cable shall be tested for cold bend at -30°C (-22°F) and impact at -40°C (-40°F). Minimum thickness of the HMWPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and a minimum of 18 strands for cable sizes larger than AWG 2. The minimum thickness of the HMWPE shall be 4 mm (0.16 inch).

Note: Cable colour should be consistent with specific installation practices.

Alternatively, an additional 1.52 mm (0.06 mm) thick red PVC outer jacket shall be extruded over the 2.78 mm (0.1 inch) HMWPE black cable.

Armoured Cable

Single conductor armoured cable shall have stranded annealed copper wire. Insulation shall conform to NEMA WC70/ICEA S-96-658, have a minimum thickness of 2.78 mm (0.1 inch) and shall be high molecular weight, medium density polyethylene (HMW-MDPE) that conforms to ASTM D 1248, Type II, Class C, Category 4, Grade J4E9. Minimum thickness of the HMW-MDPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and 19 strands for cable sizes larger than AWG 2. The middle layer shall consist of aluminum armour.

Multiconductor armoured cable shall be Teck 90, conforming to CSA C22.2 No. 131, or an ASTM equivalent. The middle layer shall consist of aluminum armour.

Single Jacket Cable – Test Leads and Sacrificial Anodes

Single-jacket cable shall be stranded copper conductor in sizes not larger than AWG 6. Insulation shall be RWU-90 XLPE (-40°C/-40°F), with a thickness of 1.83 mm (5/64") and conform to CSA C22.2 No. 38, or an ASTM equivalent.

Deep Anode Lead Cable

To resist chemical attack, cable for deep anode bed applications shall be ethylene chlorotrifluoroethylene (ECTFE) fluoropolymer (HALAR or equivalent) jacketed.

Dual-extrusion HALAR cable shall have stranded annealed copper wires. Insulation shall be a homogenous wall of natural ECTFE fluoropolymer (HALAR or equivalent) extruded over the conductor. Insulation shall conform to NEMA WC70/ICEA S-96-658 and the outer insulation shall be high molecular weight polyethylene conforming to ASTM D 1248, Type 1, Class C, Category 5, Grades E5 and J1. Average thickness of the HALAR insulation shall be 0.5 mm (0.02 inches). Minimum thickness at any point shall be not less than 90% of the specified average thickness. Average outer jacket insulation thickness shall be 1.6 mm (0.06 inches). The minimum thickness shall be not less than 80% of the specified average thickness. The completed cable shall be tested in accordance with the requirements of NEMA WC70/ICEA S-96-658.

5.2.4 Summary

Table 5-1 provides a summary of the cable specifications.

Table 5-1: Summary Cable Specifications

Description	Insulation Description	Insulation Thickness (min mm)	Insulation Thickness (min inch)	Colours Specified
Armoured cable, AWG 2, 4	Inner: HMW-MDPE	2.78	7/64	N/A
	Middle: Aluminum armour	Standard	Standard	N/A
	Outer: Colored PVC	1.52	1/16	Per site specific construction drawings
AWG 2, 4 mainline positive cable (Option 1)	Inner: HMW-MDPE	2.78	7/64	Black
	Outer: Coloured PVC	1.52	1/16	Red
AWG 2, 4 mainline positive cable (Option 2)	HMW-MDPE	4.00	5/32	Red
AWG 2, 4 Alberta positive cable	HMW-MDPE	2.78	7/64	Black
AWG 4 negative cable	HMW-MDPE	2.78	7/64	White
Single jacket cable AWG 6	RWU-90 XLPE (-40°C/-40°F)	1.83	5/64	Per site specific construction drawings
Single jacket cable AWG 8	RWU-90 XLPE (-40°C/-40°F)	1.83	5/64	Per site specific construction drawings

Table 5-1: Summary Cable Specifications (Cont'd)

Description	Insulation Description	Insulation Thickness (min mm)	Insulation Thickness (min inch)	Colours Specified
Single jacket cable AWG 10, 12	RWU-90 XLPE (-40°C/-40°F)	1.83	5/64	Per site specific construction drawings
Dual extrusion (HALAR or approved equivalent)	Inner: ECTFE fluoropolymer	0.5	2/100	Per site specific construction drawings
	Outer: ASTM D 1248 (colored)	1.6	1/16	Per site specific construction drawings
No. 2 ACSR	N/A	N/A	N/A	Per site specific construction drawings

For shipping, all cables (i.e., anode lead wires, cable spools and test station wires) shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.2.5 Splice Kits

Splice kit specifications are as follows:

- Epoxy splice kits shall contain a plastic mold, which completely surrounds the crimped cable connection and seals the cables such that the epoxy does not leak out during the cure time. Kits shall contain tape to seal the points at which the cables enter the plastic mold. Epoxy mixture shall cure in 30 minutes at temperatures of 15°C (60°F) and above. Kits shall also be rated up to 1000 volts.
- Heat shrink splice kits shall contain, as a minimum, an adhesive coated polyethylene sleeve, mastic filler and black cloth tape, or a Company approved equivalent. The sleeve shall extend 50 mm (2 inches) beyond each end of the connection. Refer to Company standard drawings.
- For splicing and sealing of continuous polymer anodes, only end caps, splice kits and tees that are approved by the conductive polymer anode manufacturer shall be used.

5.2.6 DC Poleline and Cables

DC poleline and cable specifications are as follows:

- The poles shall be minimum 12.2 metres (40 feet) long, Class 5, with Penta #8 retention, or CCA-peg treatment.
- The conductor shall be No. 2 ACSR cable, unless specified otherwise.
- Rock anchors for the poles shall be Tri-Anchor Line Pole Rock Anchor type 8-18-28.
- All pole line hardware shall be galvanized according to Ontario Hydro Electrical Safety Code, Section 75, or equivalent.

- Guy wires shall be stranded steel. The wires shall be galvanized and have a diameter of 9 mm minimum. Guy guards are required at all installed locations. Guy guards are to be made of plastic, and provide visual identification for public safety. The guards shall be secure to the guy wire using the manufacturer's supplied hardware.
- Insulators shall be selected in accordance with Ontario Hydro Specifications 31, 32, 33, or Table 100 or equivalent.

5.3 Coke and Other Backfill

5.3.1 General

All coke supplied shall be calcined, and all coke tests shall be conducted as per the referenced test methods.

5.3.2 Chemistry

The composition and tests methods are based on dry weight, and are outlined in Table 5-2.

Table 5-2: Test Methods and Coke Composition

Category	Test Method	Shallow Anodes	Deep Anodes	Continuous Polymer Anodes
Carbon (fixed)	ASTM D3172 or D5142	98.7% minimum	99.2% minimum	99.2% minimum
Ash	ASTM D3174 or D5142	0.60% maximum	0.60% maximum	0.60% maximum
Sulfur	ASTM D4239	6% maximum	6% maximum	6% maximum
Moisture	ASTM D3173 or D5142	0.20% maximum	0.20% maximum	0.20% maximum
Hydrogen	ASTM D5373 (ultimate analysis for hydrogen content)	0.10% maximum	0.10% maximum	0.10% maximum

5.3.3 Other Requirements

Coke for deep anodes and continuous polymer anodes shall be dust-free. No de-dusting oils shall be used in the manufacture of the calcined coke.

Coke shall meet or exceed the requirements outlined in Table 5-3.

Table 5-3: Other Requirements for Coke

Category	Test Method	Shallow Anodes	Deep Anodes	Continuous Polymer Anodes
Bulk density	Modified ASTM D4292	≥975 kg/m3	≥1,100 kg/m3	≥1,100 kg/m3
Resistivity	carbon industry test C12A @ 150 psi (dry basis)	<0.2 Ωcm	<0.2 Ωcm	<0.2 Ωcm
Particle size	ASTM D293 or ASTM D4749	#4 Mesh - 95% #200 Mesh - 5%	#12 mesh -100% #200 mesh - 5%	#12 mesh - 100% #200 mesh - 5%

Note: Particle size is listed as a percentage of coke passing through the screen.

For deep and continuous anode installations, Loresco SC-3 Coke Breeze, TC-Alcoke/Z0637 Coke Breeze and Asbury 251-P Coke Breeze, or a Company-approved equivalent are acceptable.

For shallow anode installations, Loresco DW-1 Coke Breeze, TC-Alcoke/Z0637, or a Company approved equivalent are acceptable.

The coke breeze supplier shall provide the Company with a "Certificate of Analysis" for each batch or lot (as specified by manufacturer) of coke breeze indicating that the coke breeze meets Company specifications.

5.3.4 Conductive Carbon Grout

Conductive carbon grout specifications follow:

- In areas where the current discharge zone could lead to the interchange flow between water-bearing formations, conductive carbon grout shall be used in the annular to form a conductive seal.
- The mixture of grout and round-grain calcined petroleum coke particles shall have additional additives to minimize the apparent viscosity of the slurry.
- The coke particles shall meet the minimum coke requirements listed above.

5.3.5 Other Backfill

The anode shall be centered in the backfill.

Backfill surrounding magnesium anodes shall have the following composition and properties:

- Gypsum – 75 to 80%
- Bentonite – 15 to 20%
- Sodium sulphate – 0 to 5%

Backfill surrounding the zinc grounding cells shall have the following composition and properties:

- Gypsum – 80 to 85%
- Bentonite – 15 to 20%
- Sodium sulphate – 0 to 5%

5.3.6 Shipping

All backfill shall be wrapped in weather and water tight UV-resistant plastic. All backfill packaging shall be clearly labelled with material designations, as specified in Sections 5.3.3, 5.3.4, and 5.3.5.

5.4 Deep Anode Venting

Deep-anode venting specifications are as follows:

- Shall allow for venting of gases a full 360-degree of the vent pipe without a loss of pipe strength.
- Vertical slits are preferred, and shall be 3.8 cm (1½ inches) in length, or greater, and shall be 0.015 cm (1/64 inch) in width.
- The diameter of piping shall be 25.4 mm (1 inch) inside diameter and 32.3 mm (1¼ inches) outside diameter.
- Material shall be non-conducting and resistant to chlorine attack, if chlorine is a possibility.
- Lengths of pipe joints shall be in either 3 metres (10 feet) or 6 metres (20 feet) lengths.
- If plowing is used, vent piping from a deep well to a vent termination point shall be 1 inch non-perforated coiled HDPE pipe. The minimum outside diameter of HDPE pipe shall be 33.4 mm (1.3 inches) and the minimum wall thickness shall be 3.02 mm (0.1 inches).

5.5 Isolation Sets

5.5.1 Flange Isolating Kit

Flange isolating kit specifications are as follows:

- These devices shall be pressure rated for the intended use, as shown on the Company standard drawing.
- Component dimensions shall conform to ANSI B16.21, Type F.
- Washers shall be zinc-plated steel.
- Retainers and double washers shall be glass reinforced epoxy (G10).
- Viton or Teflon shall be used as the sealing element.
- Minlon or Mylar insulation sleeves shall be used with insulation sets.

5.5.2 Monolithic Isolators

Monolithic isolator specifications are as follows:

- Metal components (excluding pipe-end pups) shall be forged steel.
- Pipe-end pups shall conform to the requirements for each installation, as specified on the purchase order or Company standard drawings.
- "Stiff" electrical isolating components shall consist of glass-reinforced epoxy composite conforming to ASTM D709, Type IV, Group G.10 requirements (G.11 is an acceptable alternative).
- Elastomeric sealing elements shall consist of nitrile butadiene rubber, conforming to ASTM D2000.
- Insulating filler materials shall consist of solventless epoxy resin.

- Adhesive sealant elastomeric materials shall be silicon.
- Each device shall be tested as follows:
  - Electrical test – each monolithic isolator shall be tested according to the requirements of the IEC 60-1 and 60-2
  - DC resistance test – each isolator shall maintain a resistance of at least 5 MΩ for one minute at an applied stress of 1000 VDC
  - AC resistance test – each isolator shall maintain a resistance of at least 1 MΩ for one minute at an applied stress of 5000 VAC (50-60Hz)

5.5.3 Isolating Unions

Isolating union specifications are as follows:

- Metal components shall be forged steel.
- Insulated against galvanic corrosion.
- Tailpiece coated with a tough baked industrial thermo-setting epoxy, bonded directly to the metal.
- Teflon shoulder gasket for extra wear resistance
- Insulating properties – exceeds 500 volts dielectric resistance

5.6 Rectifiers

5.6.1 General Information

General specifications for rectifiers are as follows:

- Rectifiers shall be designed to operate continuously at temperatures between -40°C and 50°C (-40°F and 122°F).
- The DC voltage output shall be fully isolated from the line voltage.
- Rectifiers shall have a primary and secondary arrestor designed to protect against electrical transients caused by lightning, induction and switching surges.
- Output ratings shall be as specified on the purchase order and Company standard drawings.
- The AC input of all rectifiers shall be single phase, 60 Hz, AC 230V, or as specified on the purchase order and Company standard drawings.
- The AC input lugs are to be sized to accommodate an AWG 2 and to provide a "dead front" for connection to the AC line.
- All rectifiers are to be equipped with an AC 115V, 15A, 3-pin ground fault interrupt (GFI) service receptacle. This receptacle is to be connected between the hot and the neutral through a fully magnetic circuit breaker from the line side of the rectifier's main circuit breaker. This receptacle is to be mounted on the front of the panel for easy access.
- Rectifying elements shall be silicon solid state and derated to 50% of the manufacturer's current rating at 100°C (212°F). Silicon diodes shall be constructed into a single-phase full wave bridge configuration. Heat sinks shall be sized to keep diode junction and core temperatures from exceeding 100°C (212°F) in 45°C (113°F) ambient conditions. Diodes shall have a minimum peak inverse voltage (PIV) of 800 V. Where applicable, clear chromate finish aluminum heat sinks (per MIL-C-5541) are acceptable. NOTE: ROHS (Restrictions of Hazardous Substances) disallows anodizing due to use of sulphuric and chromic acids.

- All cables, including jacket materials, shall be suitable for handling, and shall be rated to operate continuously over a temperature range -40°C to +105°C (-40°F to 220°F) ambient air temperature. Alternatively, all cables shall have the insulated jacket coatings de-rated according to applicable electrical codes or standards (Canadian and US) to satisfy the ambient air-temperature operating range.

5.6.2 Enclosure

Enclosure specifications are as follows:

- Enclosures for air-cooled cathodic protection rectifiers shall be constructed to CSA Enclosure 3R Classification, as required by CSA C22.2, No. 107.1 or NEMA MR 20 and NEMA MR 250. The rectifier case shall be NEMA 3R, and completely weatherproof for outdoor use.
- Minimum sheet metal thickness shall be 12 gauge wiped coat mill galvanized steel, as per ASTM 123 and, when practical, the cabinet shall be equipped with a slide-out chassis. Enclosures shall be vented for natural air convection and screened against insects. Screens shall be reinforced to provide structural integrity to the rectifier cabinet. Screens over openings shall meet the requirements set forth by CSA C22. No. 107.1. Hinges and enclosure assembly bolts shall be of stainless steel.
- Enclosures shall be painted white (or as otherwise specified), with the Company rectifier number or identifier in 50 mm to 75 mm (2 inches to 3 inches) black lettering on the outside of the front cabinet door and equipped with a pad lockable draw latch, consisting of a heavy-duty, single-hasp draw latch.
- Either a pole-mounting bracket or legs on the bottom (minimum length 600 mm [24 inches]) so it can be platform mounted, shall be provided and will be specified on the purchase order.
- Electrical panels shall be minimum thickness of 4.7 mm of (0.2 inches) NEMA Grade 'XX' phenolic. For panels greater than 100A, NEMA Grade 'UTR' type shall be used.
- All electrical hardware shall be copper, or brass finished in electroless nickel plate. All connections shall be made secure with lockwashers and nuts torqued in accordance with manufacturer's recommendations.
- For all rectifiers, a flush-mount outdoor wall plate (Leviton part #4925-2) is to be installed and if possible it is to be located on the bottom of the rectifier cabinet adjacent the closest side, or back wall, of the rectifier cabinet nearest the low voltage interruption plug and adjacent to the 200 mm x 250 mm x 150 mm (10 inches x 10 inches x 6 inches) equipment bay. The access port shall have a hinged and environmentally sealed cover. The cover hinge shall also be spring loaded for closure.
- The enclosure shall have the appropriate dimensions to accommodate an empty space for other equipment. The equipment bay is to be located on the bottom of the rectifier, adjacent to the access port described in the previous bullet. The free and clear dimensions of the equipment bay are to be 250 mm x 250 mm x 150 mm (10 inches x 10 inches x 6 inches). The equipment bay dimensions do not include the volume taken by the access port.

5.6.3 Transformer and Efficiency Filter Construction

Transformer and efficiency filter construction specifications are as follows:

- The transformer is to be designed as full isolation with separate and isolated primary and secondary windings, with a minimum efficiency of 95% at the maximum-rated voltage output.
- Transformer magnet wire and insulation materials are to be rated for CEC Class H (180°C) or NEC Class F (355°F), as applicable. Insulating materials shall be dipped in a thermosetting varnish and baked. Varnish shall meet or exceed the CSA requirements for Class H or NEC requirements for Class F operations, as applicable. Transformer voltage regulation shall not exceed 3% from full-rated load to no load.
- Dielectric strength of all insulating materials shall not be less than 2000 V RMS, as tested for one minute when applied between windings and the transformer core.
- The transformer shall be equipped with a minimum of 25 tap bar steps of secondary voltage adjustment (five coarse and five fine).
- Rectifier input overload and short-circuit protection shall be accomplished by magnetic circuit breakers; one pole per input line of AC power. Circuit breakers must trip at 140% of the rated AC input capacity of the rectifier. The input shall be labelled.
- Rectifier output over-load and short circuit protection shall be achieved by rectifier fuses in the transformer secondary of the rectifier. Rectifier fuses shall be sized for 120% rated transformer secondary RMS current. The output shall be labelled. (When the secondary fusing requirement exceeds 90 amps AC, the electronic Fuse Replacement Module will be considered as an acceptable alternative).
- Where specified, an efficiency filter (choke) shall be provided in the negative output of the rectifier. In the case of a multi-circuit rectifier, each circuit shall be provided with a choke, as mentioned. The choke shall be connected between the stack negative and the negative bus.

5.6.4 Instrumentation

Instrumentation specifications are as follows:

- The rectifier shall be equipped with multi-position switch(s) to connect a digital ammeter and voltmeter into each rectifier circuit, or pipeline negative lead. In addition, the multi-position switch shall have an "off" position that leaves the meter disconnected. The multi-position switch will also have a "lines" position, which activates a second switch that will connect each pipeline into the digital ammeter. In other words, two eight position rotary switches with the following settings:
  - Primary rotary switch – "Off, Circuit 1, Circuit 2, Circuit 3, Circuit 4, Circuit 5, Circuit 6 and Line" labels
  - Secondary line rotary switch – "Line 1, Line 2, Line 3, Line 4, Line 5, Line 6, Line 7, Bond" labels

  This represents a case for a six-circuit rectifier connected to seven pipelines and one bond. Switch types and configurations may be varied according to the number of rectifier circuits, pipelines or bonds that must be metered. The off position for the primary switch shall isolate the ammeter and the voltmeter from any internal and external signal sources.

- The ammeter and voltmeter panel displays shall be high-intensity light emitting diode (LED) displays, with a minimum 13.2 mm (0.52 inch) digit height. All metered readings shall maintain a displayed measurement accuracy to one decimal place (i.e., 0.1 Volts or 0.1 A). The ammeter shall have a minimum 3.5 digit display, and the voltmeter shall have a minimum 4 digit or 4.5 digit display. Both metres shall be auto zeroing and auto calibrating, during the manufacturer's initial setup. The required nominal voltage measurement range for the ammeter is ±199.9 mV (with the display scaled to the shunt ratings), and for the voltmeter it is ±199.9 volts (displayed as measured).
- Both the ammeter and voltmeter shall have an accuracy of ±0.10% (or two counts) at 25°C (77°F). The drift in measurement accuracy shall not exceed ±0.50% at a temperature of -40°C (40°F). Test data documenting the accuracy of both the ammeter and the voltmeter over a -40 to +80 °C (40°F to175°F) temperature range shall be provided to verify the accuracy criteria outlined above. The Company shall approve the digital ammeters and voltmeters before purchase.
- The power supply for the high-intensity LED ammeter and voltmeter shall have a dedicated on/off switch, and a protective fuse installed downstream of the AC input surge arrestor for the rectifier.
- The 50A/50 mV metering shunts shall be the panel-mounted Holloway type 'SW' style, with an accuracy of ±0.25%, where output currents are less than or equal to 50 A DC on any structure or rectifier circuit being measured. The Mobiltex or manufacturer of other existing remote monitoring units (RMUs) can measure shunt voltages ± 158 mV. Where currents to be measured exceed 50 A DC, the provisions two bullet points below shall be used. For the digital ammeter, the following shunt sizes are compatible with the ammeter: 50 A/50 mV, 100 A/100 mV and 200 A/200 mV.
- Where line return currents or individual rectifier circuit outputs are less than, or equal to, 50 A DC, the shunts shall be 50 mV and sized for the maximum rectifier output current for negative drains, and shall be installed in each "line" negative output of the rectifier, including bonds. A separate 50 mV shunt, also sized for the maximum rectifier (single circuit) or circuit output (multi-circuit units) current shall be placed to provide metering for each different circuit's output. The shunt voltage shall be a negative common mode voltage for compatibility with the RMU.
- Where line return currents or individual rectifier circuit output currents exceed 50 A DC, two shunts shall be installed in series on each rectifier circuit or line return exceeding the 50 A DC limit. The first shunt installed shall be a 50 mV shunt, sized as previously outlined in this section, and shall be dedicated to the sense leads for the RMU pre-wire. A second shunt shall be installed downstream of the first, with a rating such that a minimum of 1 mV of voltage drop occurs across the shunt for each 1 A of current (i.e., 100 mV – 100 A shunt) to be measured by the high intensity LED digital ammeter.

5.6.5 Terminals

Negative Output Terminals

When specified, all rectifier negatives, including those for multi-rectifier units, shall be bused together using removable shorting bars. The bars shall be placed after the choke (where applicable) on the negative side of the negative meter shunts on each circuit, and fed to one set of output terminals (lugs). The output terminals are to be labeled "Line 1", "Line 2", etc. Output terminal lugs are to be sized to accommodate up to an AWG 1/0, unless otherwise specified.

Positive Output Terminals

Separate positive output terminals are to be provided with each circuit, and are to be labelled. The output terminal lugs are to be sized to accommodate up to an AWG 1/0, unless otherwise specified.

Bond Terminals

Terminals labeled "bonds" shall always be provided as specified on the purchase order or Company standard drawings. Bond terminals are to be directly connected to the negative bus. Shunts for bond connections shall also be provided, if indicated on the purchase order or Company standard drawings. Bond terminal lugs are to be sized to accommodate an AWG 1/0, unless otherwise specified.

Remote Monitoring Unit (RMU) Pre-Wire

RMU pre-wire specifications are as follows:

- Optional, based upon site-specific requirements.
- All rectifiers requiring remote monitoring shall be pre-wired with sense cabling connected to a termination block
- Current measurement shunts (50 mV) for each rectifier circuit shall be located on the return side of each rectifier circuit to provide a negative common-mode voltage with the drain terminals. Sense cables shall be installed across each 50 mV shunt installed on the negative return for each rectifier circuit and negative line drains. These sense cables shall be labelled and terminated.
- As specified by the Company, voltage dividers shall be provided on sense cabling for each rectifier circuit to meet the specifications in Table 5-4.

Table 5-4: Voltage Divider Specifications

Rectifier Circuit Rating	Scaling Factor	RMU Metered Voltage into Pre-Wired Terminal Block
>150 Volts	10 : 1	0 – 20 Volts
0 – 150 Volts	1 : 1	0 – 150 Volts

- These dividers shall be installed in conjunction with the standard RMU pre-wire, as specified by Company. If no voltage dividers are called for, then the sense cables are to carry rectifier circuit line voltages, and are to be terminated.

- Sense cables shall be provided for all bonds to foreign structures, to measure both the bond current and the pipe-to-soil voltage on the foreign structure. In addition, the bond measurement facilities must ensure compatibility with the RMU. The channels allocated for measurement of bond currents and voltages shall have an option provided for full electrical isolation.
- This option is to be provided, as specified by the Company. If no electrical isolation devices are specified, then an empty terminal is to be left for the foreign structure sense lead (non-current carrying) and leave a blank terminal for a fixed reference cell lead. The 50 mV foreign structure current measurement shunt(s) shall be installed in series with the current carrying bond lead, and shall have sense leads terminated.
- Sense cables allocated to fixed reference cells must also ensure compatibility with the RMU.
- All sense cables shall be AWG 12 in size and have jacket materials compatible with the operation within the environment inside the rectifier cabinet. The sense cables, including jacket materials, shall be suitable for handling over a temperature range -40°C to 105°C (-40°F to 220°F) ambient air temperature. A control transformer shall be installed in each rectifier unit for future power for the RMU5 remote monitoring device.

Low-Voltage Interruption Terminal

Low-voltage interruption terminal specifications are as follows:

- All rectifiers shall be wired with a CONXALL 4282-5SG-300 (including 4295 dust cap) 5-pin female connector. The wiring associated with the plug shall be AWG 20 TEW stranded copper cable rated to operate up to 105°C (220°F) temperature. Wire terminations for the connector are to be made as per Section 5.6.9.
- The CONXALL 4282-5SG-300 5-pin female connector shall be installed on the rectifier's front phenolic panel to allow the 4295 dust cap to have a minimum clearance of 51 mm (2") from the rectifier cabinet door.
- The AC interruption relays shown in Table 5-5 shall be installed in parallel with the high-voltage twist-lock hubble connector across the interruption switch located on the L1 leg of the AC power supply wiring downstream of the AC surge suppressor (See Section 5.6.9).

Table 5-5: AC Interruption Relays

Rectifier AC Power Input Rating	AC Relays Types	AC Relay Model Numbers
0 – 50 A	Crydom Series 1	Model D2450-10
>50 A	Crydom Series 1	Model D24110-10

- All AC relays shall be installed with heat sinks appropriately sized to facilitate continuous operation of the AC relay under interruption.
- A Hammond BD2E 12 volt power supply transformer is to be installed to power terminals four and five on the CONXALL 4282-5SG-300 5-pin female connector. The input leads on the transformer are to be wired into the L1 AC supply lead, downstream of the AC surge suppressor, and the second lead is to be wired into the AC neutral (see Section 5.6.9).

- The wiring for the CONXALL 4282-5SG-300 5-pin female connector and the Crydom relays, as outlined previously in this section, shall be compatible with the Mobiltex CorrTalk Portable Interrupter Model SPI-1A, SESCO GPS timing device model TCMAD1-100, or SESCO GPS current interrupter model TCFAD1-100 in synchronously actuating the relays with respect to pre-set GPS time-based interruption intervals.

5.6.6 Lightning Protection

Lighting protection specifications are as follows:

- Unless otherwise specified, metal oxide varistor arrestors shall be installed on both the AC input and the DC output of the rectifier.
- An arrestor shall be placed between the chassis and DC positive of each circuit, DC negative of each circuit and the chassis ground.
- Where semi-conductor or valve type arrestors are used, they are to be in an accessible location and enclosed in a small metal enclosure. The enclosure is to prevent fire in the event of a fault or surge.
- Arrestors are not to be mounted on the front control panel.

5.6.7 Inspection and Testing

Testing

All units shall be subjected to tests that verify that specifications are met. Documentation of these tests shall be provided.

Dielectric Strength Tests

Dielectric strength-test specifications are as follows:

- Every transformer shall be subjected to dielectric strength tests, conducted as per CSA C22.2 No. 107.1, or UL 60950, or NFPA 70 as applicable.
- Dielectric strength tests shall be conducted on the transformer before varnish dipping and baking, and after baking. The after baking test can be included as part of the final rectifier dielectric test.
- All assembled rectifiers shall be subjected to dielectric strength tests, as outlined in CSA C22.2 No. 107.1, or UL 60950, or NFPA 70 as applicable.

Inspection

After assembly, the rectifier shall be subjected to inspection of all wiring and mechanical components and their connections. Inspection shall also include over-all workmanship.

Operation

Rectifiers shall be subjected to testing and recording of all rectifier electrical parameters as follows:

- AC input voltage, current, apparent power and true power
- DC output voltage, current and power
- AC power factor
- AC to DC conversion efficiency

If a filter is required, the ripple at full output voltage shall be measured and documented.

Rectifier metres shall be tested to meet the requirements specified in Section 5.7.4.

5.6.8 Shipping

A rectifier identification plate shall be firmly attached on the inside of the cabinet door, and shall contain the following:

- Manufacturer's name and code number
- AC volts and amperes
- line frequency
- number of phases
- DC voltage and ampere ratings
- ambient temperature rating
- serial number
- CSA file number (as applicable)

The following items are to be in a waterproof enclosure with documentation in the rectifier door, or if specified, label using lamacoid plates, or an equivalent approved by Company cathodic protection engineering personnel. Labels are to have a black background and white lettering.

- AC rectifier input terminals
- transformer tap positions (coarse & fine)
- negative and positive output lugs
- all metres
- Switch positions
- main breaker
- DC and AC arrestors
- all fuses (size and type)
- interrupter mode switch
- interrupter receptacle
- utility receptacle
- high voltage (if applicable)

A circuit diagram and parts list shall be included with each rectifier. The rectifier drawing shall be laminated and mounted on the inside of the front door of the rectifier. In addition, a paper copy of the rectifier electrical schematic and a parts list for each rectifier detailing all of the components shall be provided to Company Cathodic Protection Engineering personnel.

Each rectifier shall be individually packaged for shipment, and shall have the rectifier name or rectifier number clearly labelled on the exterior of the shipping box.

5.6.9 Rectifier Circuit Diagram

Refer to the Company standard drawings, or as per the Company's instruction.

5.7 Thermoelectric Generators

5.7.1 General Information

General specifications for thermoelectric generators are as follows:

- TEGs shall be designed to operate at temperatures between -45°C and 65°C (-50°F and 150°F).
- TEGs shall be designed to operate in unlimited rain or snowfall, provided that the unit is not flooded.
- TEGs shall operate in 100% relative humidity.
- TEGs shall operate in wind gusts of up to 140 km/hr (85 mph).
- TEGs shall come complete with automatic re-ignition.
- All components shall be manufactured in modules, or assemblies for easy field maintenance.
- As necessary, the units shall be furnished with over-temperature protection circuitry.

5.7.2 Enclosure

Enclosure specifications are as follows:

- Enclosures shall be designed for outdoor installation, and be of stainless steel and aluminum construction.
- Enclosures shall be equipped with pad-lockable latches.
- All electrical hardware shall be copper, or brass finished in electrolysis nickel plate. All connections shall be made secure with lockwashers and nuts, or with compression-type terminals.
- Enclosures shall be identified with the Company's rectifier number, or identifier in 50.8 mm to 76.2 mm (2 inch to 3 inch) black lettering on the outside of the front cabinet.

5.7.3 Mechanical Construction

Mechanical construction specifications are as follows:

- Units shall have a lead telluride solid-state, hermetically sealed power unit.
- Units shall have a nickel-alloy construction, meeker-type burner design that is stable in normal operating conditions.
- The individual TEG(s) shall be ordered to operate on butane, propane or natural gas, depending on the available fuel supply.

5.7.4 Metering and Instrumentation

Metering and instrumentation specifications are as follows:

- A separate suitably scaled voltmeter and ammeter as well as a current measuring shunt shall be provided to measure the DC output.
- Metres shall be a minimum 90 mm (3½ inches) size, with a minimum scale length of 73 mm (2⅞ inches).
- Metering accuracy shall be ±2% of full-scale deflection at 25°C (77°F). Temperature compensation shall be no more than 0.85% per 10°C (50°F), for temperatures other than 25°C (77°F).
- The package shall contain a terminal block capable of accepting 2/0 AWG (9 mm or ⅜ inch) cable.
- The package shall contain a variable resistor designed to control current output.
- Electrical output isolation from the chassis shall be achieved such that the leakage current does not exceed 100 mA.

5.7.5 Inspection and Testing during Manufacture

Inspection and testing specifications during manufacturing are as follows:

- All units shall be subjected to testing at 100% of rating.
- All units shall be subjected to tests as outlined in SPE-1000-94 for dielectric strength, bonding continuity, leakage current, stability and temperature.
- All units shall be subjected to testing and recording of all performance parameters as follows:
  - DC output voltage, current and power
  - DC input voltage, current and power
  - fuel pressure for rated power
  - set up voltage for rated power
  - leak test of fuel system
  - verification of ignition system operation

5.7.6 Shipping

An identification plate shall be firmly attached on the inside of the cabinet door, and shall contain the following:

- Manufacturer's name and code number
- serial number
- fuel usage
- fuel pressure setting

5.8 Solar-Power Units

5.8.1 General Information

General specifications for solar-power units are as follows:

- Solar-power units shall be as specified on the purchase order.
- The number of solar panels to deliver the requirements as specified in the purchase order, or Company standard drawings, shall be determined by the manufacturer or distributor.
- The size of the units (typically 12V DC or 24V DC) shall be specified on the purchase order or Company standard drawings.
- All solar-power units shall have a main disconnect switch between the solar panels and the controller.
- All solar-power units are to be supplied with a silicon oxide varistor lightning arrestor with:
  - clamp voltage 100 V
  - maximum operating voltage 48V DC
  - maximum current 50 kA
  - maximum energy 750 Joules (0.7 BTU)
  - unlimited number of surges
  - 10 nanosecond response time

  They are also to be supplied with a system electrical groundlug.

5.8.2 Panels

Panel specifications are as follows:

- Solar panels shall be mounted on 12 metres (40 feet) of Class 6 wooden utility poles.
- The diameter of the pole at the panel-mounting location is to be approximately 200 mm (8 inches).
- Mounting brackets to secure the solar panels shall be sized to accommodate attachment to the highest point on the utility pole.

5.8.3 Controllers

Controller specifications are as follows:

- Controllers shall be sized to accommodate the voltage and the current requirements as specified on the purchase order or Company standard drawings.
- Controllers shall have a continuous voltage and current display.
- Controllers shall be housed in a watertight enclosure with securable locking latches or handle.

5.8.4 Batteries

Battery specifications are as follows:

- All units shall be supplied with either absorbed glass mat (AGM) or gel-sealed batteries, as specified on the purchase order. The self-discharge rate of the battery must be less than 2% per month, and must have a 12-month warranty.
- Battery quantities and sizes shall be to provide a minimum of 72 hours autonomy, with no more than 50% depth of discharge.
- Batteries shall be housed in a separate insulated and vented battery box.
- The battery box is to have securable locking latches or handles. The battery box is to have mounting lugs to secure the box to a wooden platform, or platform approved by Company Cathodic Protection Engineering personnel.

5.8.5 Enclosure

Enclosed specifications are as follows:

- Power center enclosures must be rated as NEMA Type 3, 3R or 4, and are to be rain and sleet proof.
- The enclosures must have a drip shield over the door.
- The hinged door is to be sealed with seamless poured urethane gasket, and come complete with a lockable latching mechanism that maintain constant pressure on the gasket.
- The battery box shall be insulated with 50 mm (2 inch) high-density foam and sized to allow a 10 mm (½ inch) battery separation and be complete with a hinged lid with a lockable latch.

5.8.6 Shipping

The location to which the units are to be shipped shall be clearly marked.

5.9 Test Stations

The test lead assembly shall be as per Company standard drawings.

5.10 Remote Monitoring Equipment

5.10.1 General Information

General specifications for remote monitoring equipment are as follows:

- All RMUs shall be CSA certified, or UL approved.
- All units shall have flash program memory.
- Internal components shall operate in the temperature range -40°C to +80°C (-40°F to +175°F).

5.10.2 Enclosures

Enclosure specifications are as follows:

- Enclosures for RMUs shall be NEMA 4X rated fiberglass or polycarbonate.
- Enclosures shall be equipped with a pad-lockable draw latch.

- All units to be fitted with a CSA or UL approved (as applicable) 10 watt heater and control thermostat to maintain the enclosure internal temperature within the radio's operating temperature range.
- Insulation shall be a "K" value suitable to allow a 10 watt heater to provide the required minimum temperature.
- Insulation to be rigid, foil backed non-hygroscopic and non-flammable to provide for a maintenance-free interior.
- Enclosure to have a mounting plate supported over the insulation, for mounting components.
- GPS antenna is to be mounted on the top of the enclosure and to be suitably sealed to prevent both the ingress of moisture and unnecessary heat loss.
- The external electronic temperature sensor shall be mounted off-centre on the bottom of the enclosure, and is to be suitably sealed to prevent both the ingress of moisture and unnecessary heat loss.

5.10.3 Channels

Channel specifications are as follows:

- All units to be equipped with 10 analog inputs and one interrupt drive output.
- All units shall have four isolated digital input points.
- All units shall have one internal (mounted on a PCB), and one external electronic temperature sensor.

5.10.4 Interruption

Interruption:

- Shall be a solid state AC interrupt relay, 25 A @ 280 VAC maximum
- Is to occur via GPS time receiver

5.10.5 Communication

IMARSAT communication is to be via Easy Track Communication/ GPS unit, with an operating temperature range of -30°C to +50°C (-22°F to 122°F).

5.10.6 Command Options

All units shall be able to indicate:

- AC "power fail" alarm. (Debounce timer set to 1 hour.)
- AC power restored. (Debounce timer set to 1 hour)
- DC power fail (DC current goes to zero, e.g. fuse fails, rectifier fails). (Debounce timer set to 1 hour.)
- Low battery (no time delay in sending this alarm)

5.10.7 Power Supply

Power shall consist of 120 VAC to 12 VDC supply for transceiver and electronics. (TEG version will be 24 VDC to 12 VDC.)

All units shall have a battery backup with charger and a low-voltage disconnect.

5.11 Junction Boxes and Terminal Boxes

5.11.1 Junction Boxes

Junction-box specifications are as follows:

- Junction box size and location shall be as per the purchase order or Company standard drawings.
- Junction box enclosures shall be cast aluminum, as per Wright Aluminum Ltd. specifications (Model# WAL-56 or Model# WAL-102).
- All junction-box enclosures shall have a high-voltage shield, and be mounted on 76 mm (3 inches) OD conduit(s), as per Company standard drawings.
- All junction boxes shall be constructed to CSA Enclosure 3R Classification, or equivalent.

5.11.2 Terminal Boxes

Terminal box specifications are as follows:

- Terminal box size and locations shall be as per the purchase order and Company standard drawings.
- Terminal boxes shall meet Hammond (Model 1418N4M8) or Bel (Model R363008) specifications.
- Terminal-box enclosures shall have a minimum sheet-metal thickness of 14 gauge.
- All steel terminal box enclosures shall be CEMA/NEMA 4 rated, and shall be powder coated (ASA61 grade polyester or ANSI/ASA61 grey baked recoatable enamel).
- Hinges and enclosure assembly bolts shall be stainless steel or aluminum. The enclosure shall be equipped with a latching device.
- All terminal box enclosures shall have a high-voltage shield, and be mounted on two 76 mm (3 inches) OD conduits as per Company standard drawings.

5.11.3 Panels

Junction box panels shall be a minimum thickness of 4.7 mm (0.2 inches) of NEMA grade 'XX' phenolic.

All electrical hardware shall be copper or brass, finished in electrolysis deposited nickel plate. All connections shall be made secure with lockwashers and nuts tightened to the manufacturer's recommended torque.

5.12 Copper–Copper Sulphate Reference Electrodes

Unless otherwise specified, all copper–copper sulphate reference electrodes shall be EDI Model UL - 30 Year LongLifeTM reference electrodes. Element type shall be a saturated gelled Cu/CuSO4. The lead wire shall be AWG 14 or larger, 15 metres (45 feet) or greater in length, insulated in high molecular weight polyethylene, and rated for underground service.

Where specified, the CSCL copper–copper sulphate reference electrode shall be CPMP-2-50. The length of the cable shall be as per the site-specific construction drawings.

5.13 NovaProbes

NovaProbe specifications are as follows:

- Permanent NovaProbes are patented and only available from licensed manufacturers.
- Permanent NovaProbes shall measure the following parameters:
  - local soil resistivity
  - local soil pH
  - local oxidation reduction potential
  - "on" pipe-to-soil potential

5.14 Coupons

Coupons shall be either 9 cm^2 or 50 cm^2 (1.4 in^2 or 9 in^2). Coupon test stations shall comply with Company standard drawings.

5.15 Exothermic Welds and Bonds

5.15.1 Thermite Welds

Thermite weld specifications are as follows:

- Thermite welds shall be a #15 gram charge (green cap) maximum with F-33 powder, or approved equivalent.
- A copper sleeve shall be used for wire sizes smaller than AWG 8. The sleeve size shall correspond to cable size.

5.16 Silver Soldering

Silver soldering specifications are as follows:

- Use only 2% silver/98% tin soldier material with the appropriate flux.
- "Tin" the pipe and the conductor to be soldered.
- Heat the pipe and melt a solder puddle sufficient in size to attach the conductor.
- Test for adequate bond and neutralize the acid flux with base solution.

5.17 Mechanical Bonds

Mechanical bond specifications are as follows:

- Circumferential clamp(s) is to maintain residual tension after the tensioning device is withdrawn. The cable connection to a circumferential clamp must be achieved by welding, or bolting to the clamping device.
- Any connection to structures, other than a pipe, must be achieved using materials required in the CEC or the NEC (as applicable) for grounding connections.
- Specially designed alteration to an electrical LB (elbow, back opens) fitting and connected to a flange bolt may be used. The apparatus shall be constructed of rigid conduit from a point 450 mm below grade and up to the LB. The cable shall pass through the conduit and connect to a lug inside the LB fitting. The conduit must be equipped with an EYS sealed fitting at the point of emergence from the ground.
- An alternate to the rigid conduit and EYS fitting is to use a single conductor Teck cable connected to the LB fitting with a "liquid tight" transition fitting.

5.18 Controlled Interference Bonds

Control device in an interference bond circuit shall consist of an appropriately sized resistor, or rheostat, and a meter or shunt.

5.19 AC Mitigation, Surge Protection and DC Decoupling

5.19.1 General Information

General specifications for AC mitigation, surge protection and DC decoupling are as follows:

- Isolation surge protectors shall be designed to simultaneously provide DC isolation and AC continuity at cathodic protection isolator locations, plus meet environmental ratings outlined in NEMA 4X and hazardous classifications for NEC, CSA: Class 1, Division 1 & 2, Groups A,B,C, D.
- Typical applications include installation where the facilities are subject to AC coupling, AC faults, or lightning, or electrical switching transients. Under AC faults or lightning (short term transients) it is allowable for the device to temporarily conduct DC current.
- The device shall be designed to allow an unlimited number of switching operations (associated with occasional AC faults or lightning events) without failure.
- The ultimate failure mode of the device shall be in the closed-circuit position.
- The device shall be equipped with two hole (⅜ inch diameter) terminal pads for cable connection.
- Isolation surge protectors shall be solid-state devices capable of normal operation at ambient temperatures between -45°C and +45°C (-50°F and 113°F).

5.19.2 Polarization Cell Replacements – Electronic Device Performance Characteristics

The performance characteristics shall be specified by the following product ratings.

- lightning surge current
- voltage threshold
- 60 Hz fault current
- 60 Hz steady-state current
- enclosure
- instrument test feature
- special requirements

If not specified on the purchase order, the following parameters shall apply:

- Lightning surge current – 50 kA: This parameter specifies the maximum current that the device must be capable of passing while holding the voltage across the terminals below 700 volts. The test waveform shall be 8 X 20uS.
- DC blocking voltage – 4.5 volts: This parameter specifies the upper DC voltage level, which will be blocked by the device while continuously conducting 60 Hz AC current.
- AC fault current at 60Hz – 50 kA for 1 cycle: This parameter specifies the minimum AC fault current that the device must be capable of passing without failure.

- Steady-state AC current at 60 Hz – 50 A RMS: This parameter specifies the maximum allowable steady state AC current that can be passed through the device while maintaining DC isolation.
- AC voltage drop under fault at 60 Hz – 35 volts AC: This parameter specifies the maximum AC voltage drop through the device under full rated fault current.

5.19.3 Enclosure

Enclosure specifications are as follows:

- Unless otherwise specified, the device shall be furnished with a NEXA 4X metallic enclosure suitable for all or channel mount, complete with a padlockable access cover.
- The device shall be marked with the manufacturer's name, the device model number and the device serial number.

5.19.4 Instrumentation

The device shall contain a sufficient number and type of test terminals to allow AC and DC voltage and current measurements while in operation. All test terminals shall incorporate a dead-front design to prevent personnel shock, and shall be clearly labelled.

5.19.5 Shipping

The device shall be packaged for shipping in order to prevent damage.

6 QUALITY MANAGEMENT

6.1 Quality Checks and Documentation

The Company requires the following reviews before and during work:

- Review that the manufacturer is approved within the Company's approved vendor list
- Review the materials adhere to the guidelines set forth in this specification

The Company requires the following documentation before work starts:

- Verification of equipment calibration, as per equipment specifications

6.2 Performance Measures

The manufacturer will be evaluated on the following measures:

- Adherence to the schedule – the ability to achieve milestones set forth by the Company.
- Delivery of materials – the materials are delivered to the Company in the timelines provided.
- Quality of materials – the materials adhere to the guidelines set forth in this specification.
- Adherence to safety – the ability to complete work safely with no lost time incidents.

6.3 Specification Deviations

Any deviations from this specification shall be identified and addressed as per the TEP-INT-MOC *Pipe Integrity Management of Change Procedure*. Deviations are to be reviewed and accepted by the Company's representative before acceptance of the deliverables, data or report.

6.4 Nonconformance Management

All nonconformances to the specification will be identified by the vendor, and reviewed and dispositioned by the Company.

APPENDIX

APPENDIX A APPROVED MATERIAL LIST

Table A-1: Approved Material List

Material Type	Manufacturer	Description	Model	Size (Metric)	Size (Imp)
Anodes	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2660	Length: 1524 mm Diameter: 66 mm Mass: 23 kg (nominal)	Length: 60 in Diameter: 2.6 in Mass: 50 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2684	Length: 2134 mm Diameter: 66 mm Mass: 31 kg (nominal)	Length: 84 in Diameter: 2.6 in Mass: 68 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	3884	Length: 2134 mm Diameter: 97 mm Mass: 31 kg (nominal)	Length: 84 in Diameter: 3.8 in Mass: 68 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2660Z	Length: 1524 mm Diameter: 69 mm Mass: 23 kg (nominal)	Length: 60 in Diameter: 2.7 in Mass: 50 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2684Z	Length: 2134 mm Diameter: 69 mm Mass: 32 kg (nominal)	Length: 84 in Diameter: 2.7 in Mass: 70 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	3884Z	Length: 2134 mm Diameter: 76 mm Mass: 41 kg (nominal)	Length: 84 in Diameter: 3.0 in Mass: 90 lb (nominal)
		Graphite Center Tap Anode	Varies depending on supplier	Length: 1016 mm Diameter: 102 mm Mass: 16 kg (nominal)	Length 40 inch. Diameter 4 inch Mass: 35 lb. (nominal)
		Graphite Center Tap Anode	Varies depending on supplier	Length: 1524 mm Diameter: 76 mm Mass: 12 kg (nominal)	Length 60 inch. Diameter 3 inch Mass: 27 lb. (nominal)

Table A-1: Approved Material List (Cont'd)

Material Type	Manufacturer	Description	Model	Size (Metric)	Size (Imp)
		Graphite Center Tap Anode	Varies depending on supplier	Length: 2032 mm Diameter: 102 mm Mass: 29 kg (nominal)	Length 80 inch. Diameter 4 inch 64 lb.
		Mixed Metal Oxide Anode	Varies depending on supplier	As specified on the purchase order.	As specified on the purchase order.

APPROVALS

Originator: Ryan McKay, P. Eng Corrosion Engineer Pipe Integrity, Corrosion Prevention	Signature	Jan 22, 2013 Date
Reviewer: Chad Khattar, P. Eng Senior Engineer Pipe Integrity, Corrosion Prevention	Signature	Jan 23, 2013 Date
Reviewer: Brent McKinnon Program Management U.S. Pipeline Maintenance Projects	Signature	Jan 24, 2013 Date
Responsible Engineer/Approver/ Engineer-in-charge/Document Contact: Brad Woloschuk, P. Eng Senior Engineer Pipe Integrity, Corrosion Prevention	Signature FEBRUARY 01, 2013 Date	PROFESSIONAL ENGINEER BRADLEY J. WOLOSCHUK 2013-02-01 APEGA Permit to Practice P7100
Accountable Manager: James Card, BSEE Manager Pipe Integrity, Corrosion Prevention	Signature	1/28/13 Date

SUMMARY

This specification establishes the requirements for cathodic protection materials for the installation of cathodic protection facilities for Company gas and hazardous liquid pipeline systems in Canada and the United States.

BRIEF DESCRIPTION OF CHANGE

REGULATORY

- N/A

GENERAL

- Editorial and format changes throughout the document.

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DEFINITIONS

Terms	
ACSR	aluminum conductor steel-reinforced cable
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
CEC	Canadian Electrical Code
CSA	Canadian Standards Association
ECTFE	ethylene chlorotrifluoroethylene
HMW-MDPE	high molecular weight high density polyethylene
HMWPE	high molecular weight polyethylene
IEC	International Electrotechnical Commission
NACE	NACE International
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
RMU	remote monitoring unit
The Company	TransCanada PipeLines
XLPE	cross-linked polyethylene

Tools and Applications	
Incident and Issue Tracking (IIT)	An electronic database tool used to report incidents and issues involving employees, contractors and third parties.
FileNet-EDMS	The Company's web-based electronic document management system.

1 PURPOSE

This specification establishes the requirements for cathodic protection materials for the installation of cathodic protection facilities for the Company's buried pipeline systems in Canada and the United States.

This specification shall be used:

- By Company employees and all prime and Subcontractors employed by the Company
- In all activities related to cathodic protection, including design, construction, operations and maintenance

Materials supplied shall meet all requirements of this specification and any additional requirements on the applicable request for quotation, purchase order and applicable Company standard drawings.

Before a material is added to the Approved Material List, it shall be reviewed and approved by the Company's Cathodic Protection Engineering personnel.

2 SCOPE

This specification applies to materials for cathodic protection for the Company's gas and hazardous liquid pipeline systems in Canada and the United States.

3 REFERENCES

3.1 Regulations, Codes and Standards

The jurisdictional regulations and legal requirements that apply to this procedure are:

- 49 Code of Federal Regulations (CFR):
  - 192, Subpart I
  - 195, Subpart H
- Canadian Standards Association (CSA):
  - Z662-11 *Oil and Gas Pipeline Systems*
  - C22.1 Canadian Electrical Code (CEC), *Part I, Safety Standard for Electrical Installations (Section 80)*
  - C22.2 No. 107.1, *General Use of Power Supplies*
  - C22.2 No. 131, *Type TECK 90 Cable*
  - C22.2 No. 75, *Thermoplastic-Insulated Wires and Cables (Tri-National standard, with UL 83 and NMX-J-010-ANCE*, 2008
  - Special Publication SPE-1000-94, *Model Code for the Field Evaluation of Electrical Equipment*
- National Fire Protection Association (NFPA) 70 National Electrical Code (NEC)

3.2 Industry Publications and References

The industry publications and references that apply to this procedure are:

- NACE International:
  - SP0169-2007, *Control of External Corrosion on Underground or Submerged Metallic Piping Systems*
  - SP0572-2007, *Design, Installation, Operations, and Maintenance of Impressed Current Deep Anode Beds*
- American Society for Testing and Materials (ASTM) International:
  - G97, *Standard Test Method for the Laboratory Evaluation of Magnesium Sacrificial Anode Test Specimens for Underground Applications*
  - B265, *Standard Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate*
  - B418, *Standard Specification for Cast and Wrought Galvanic Zinc Anodes*
  - B843, *Standard Specification for Magnesium Alloy Anodes for Cathodic Protection*
  - A518, *Standard Specification for Corrosion-Resistant High-Silicon Iron Castings*
  - D1248, *Standard Specification for Polyethylene Plastics Molding and Extrusion Materials For Wire and Cable*
  - D2000, *Standard Classification System for Rubber Products in Automotive Applications*
  - B3, *Standard Specification for Soft or Annealed Copper Wire*
  - B8, *Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft*
  - D293, *Standard Test Method for the Sieve Analysis of Coke*
  - D709, *Standard Specification for Laminated Thermosetting Materials*
  - D3172, *Standard Practice for Proximate Analysis of Coal and Coke*
  - D3173, *Standard Test Method for Moisture in the Analysis Sample of Coal and Coke*
  - D3174, *Standard Test Method for Ash in the Analysis Sample of Coal and Coke from Coal*
  - D3178, *Standard Test Method for Ultimate Analysis for Hydrogen Content*
  - D5142, *Standard Test Methods for Proximate Analysis of the Analysis Sample of Coal and Coke by Instrumental Procedures*
  - D4239, *Standard Test Methods for Sulphur in the Analysis Sample of Coal and Coke Using High Temperature Tube Furnace Combustion Methods*
  - D4749, *Standard Test Method for Performing the Sieve Analysis of Coal and Designating Coal Size*
- American Society of Mechanical Engineers (ASME) B16.21, *Nonmetallic Flat Gaskets for Pipe Flanges*
- International Electrotechnical Commission (IEC):
  - 60060-1, *High-voltage test techniques, Part 1: General definitions and test requirements*
  - 60060-2, *High voltage test techniques, Part 2: Measuring systems*
  - 60228, *Conductors of Insulated Cables*

- National Electrical Manufacturers Association (NEMA):
  - WC70/ICEA S-96-658, *Thermoplastic Insulated Wire & Cable for Transmission & Distribution*
  - Standard Publication No. MR 20-1958 (reaffirmed by NEMA 1971) – *Semiconductors, Rectifiers, Cathodic Protection Units*
  - Standard Publication No. MR 250-1979 (including Rev No. 1 December 1980), *Enclosures for Electrical Equipment (1000 Volts Maximum)*

3.3 Internal References

The Company procedures, guidelines, reports and documents that apply to this specification are:

- *Operations and Maintenance (O&M) Manual U.S. Natural Gas Pipelines* (EDMS No. 005404490)
- *Operations and Maintenance (O&M) Manual U.S. Hazardous Liquids Pipelines* (EDMS No. 005713585)
- *Operator Qualification Program* (EDMS No. 004504739)
- TEP-INT-MOC *Pipe Integrity Management of Change Procedure* (EDMS No. 006425143)

4 ROLES, RESPONSIBILITIES AND QUALIFICATIONS

4.1 Manufacturer's Responsibilities

4.1.1 Requirements for All Materials

Following are material requirements:

- The manufacturer shall be on the Company's cathodic protection Approved Materials List (see APPENDIX A) for the production of cathodic protection materials.
- At the request of the Company Representative, cathodic protection material may be retained by the Company for evaluation to ensure the material conforms to this specification.
- The Company shall have the right to review the manufacturer's work at any time.
- The manufacturer shall supply to the Company at the time of quotation any exceptions or alternatives to this specification.

4.1.2 Preproduction Provisions

For isolation sets, the manufacturer shall submit to the Company the following:

- For each sleeve size, the inside diameter (ID), outside diameter (OD), thickness and length (all in millimetres or inches), material type, and the dielectric strength (volts per 1 mm or inch).
- For each washer type and size, the ID, OD and thickness (all in millimetres or inches), material type, and if applicable, dielectric strength (volts per 1 mm or 1 inch).

For rectifiers, the manufacturer shall submit to the Company:

- A certification that the rectifier meets the requirements of this specification
- A nationally recognized testing laboratories (NRTL) approval certification
- A circuit diagram and dimensions of the enclosure

For:

- Thermoelectric generators (TEG), the manufacturer shall certify that the TEG(s) meet the requirements of this specification, and provide a diagram showing the components of the TEG(s) and dimensions of the enclosure(s).
- Calcined coke, the manufacturer shall submit a datasheet detailing the chemistry and other requirements in Section 5.3.
- Cables, the manufacturer shall certify that the cable meets the requirements of the CEC or the NEC (as applicable), ASTM D 1248 or NACE Standard SP0572 and this specification.
- Each monolithic isolator, the manufacturer shall submit to the Company the fabrication drawing and the production schedule.
- Remote monitoring equipment and rectifiers, the manufacturer shall supply laminated electrical schematic drawings with each rectifier, and copies shall be submitted to the Company.

4.2 Company Responsibilities

The Company representative shall obtain all QA/QC documents for materials to be installed, in accordance with the project description.

5 CATHODIC PROTECTION MATERIALS – REQUIREMENTS

5.1 Anodes

5.1.1 High-Potential Magnesium Anodes

Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass and dimensions are as follows:

- The anode shall conform to ASTM B843, Grade M1C.
- The anode shall have a minimum efficiency of 43%, when tested in accordance with ASTM G97.
- The mass of the anode, anode dimensions and package dimensions shall be as specified on the purchase order.
- A galvanized steel core shall be cast at least 75% of the full anode length.

Lead Wire

See Section 5.2.2, Magnesium Anodes or Zinc Anodes.

Backfill

See Section 5.3.5.

Markings

The anode type, mass (kg/lbs) and Company specification and revision date shall be legibly marked on each anode package with a weather-resistant marker or a label (e.g., High Potential Magnesium, 15 lbs, TES-CP-MS [Cdn-US], 2012/10/01).

Shipping

Shipping specifications are as follows:

- The backfill package shall consist of a cotton bag or wettable (e.g., no wax or plastic coated) cardboard tube with the dimensions as specified on the purchase order.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.1.2 Zinc Ribbon

Chemical Composition, Mass and Dimensions

Chemical composition, mass and dimension specifications are as follows:

- The chemical composition of zinc ribbon shall conform to ASTM B418, Type II. The anode dimensions shall be as specified on the purchase order or Company standard drawings.
- The anode shall be manufactured by extrusion with a continuous centered 1/8" galvanized steel core.

Lead Wire

Not applicable.

Backfill

Not Applicable.

Markings

The following shall be legibly marked with a weather-resistant marker on a tag attached to the reel (or other device anode is wrapped around):

- manufacturer
- anode model
- ribbon type
- cross section (X millimetres [inches] x Y millimetres [inches])
- length (metres or feet)
- Company specification and revision date

For example, “manufacturer”, aaa, zinc ribbon, 12 mm x 15 mm, 500m, TES-CP-MS (Cdn-US), 2012/10/01.

Shipping

Shipping specifications are as follows:

- The ribbon shall be packaged in a manner to allow for ease of shipping.
- The zinc ribbon shall be prepared for shipment and storage in such a manner that it will not be exposed to weather or water, as directed by the supplier.

5.1.3 Zinc Grounding Cells

Chemical Composition, Mass and Dimensions

The chemical composition for the zinc shall conform to ASTM B418, Type II. The anode dimensions shall be as specified on the purchase order or Company standard drawings.

Lead Wire

See Section 5.2.2, Magnesium Anodes or Zinc Anodes.

Backfill

See Section 5.3.5.

Markings

The anode type, mass (kilograms or pounds) and the Company specification and revision date shall be legibly marked on each anode package with a weather-resistant marker or a label (e.g., Zinc Grounding cell, 7.7 kg, TES-CP-MS [Cdn-US], 2012/10/01).

5.1.4 Silicon-Chromium Cast Iron Anodes

Chemical Composition, Mass and Dimensions

The following clauses shall apply to both tubular and stick anodes castings:

- The anode shall be chill cast or equal, from an alloy conforming to ASTM A518 GR3.
- Each anode shall be supplied free from casting defects, porosity, voids and fissures. The anode surface shall be free from adhering foundry sand or mould release agents.
- The anode mass and anode dimensions shall be as specified on the purchase order or Company standard drawings.
- All anode manufacturers shall be approved by the Company.

Lead Wire

See Section 5.2.2, Tubular Anodes.

Backfill

See Sections 5.3.1 to 5.3.4.

Markings

The following shall be legibly marked with a weather-resistant marker on a tag attached to the anode:

- manufacturer
- anode model
- anode type
- anode mass (kilograms or pounds)
- anode OD (millimetres or inches)
- length (millimetres or inches)
- Company specification
- revision date

For example, “manufacturer”, aaa, stick, 20 kg, 50 mm, 1520 mm, TES-CP-MS (Cdn-US), 2012/10/01.

Shipping

Shipping specifications are as follows:

- Anodes shall be packaged in a manner to avoid breaking during shipment.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water, as directed by the supplier.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.1.5 Continuous Polymer Anodes

Chemical Composition, Mass and Dimensions

Specifications for chemical compositions, mass and dimensions are as follows:

- Continuous polymer anodes shall be constructed as stranded American Wire Gauge (AWG) 6 annealed copper conductors with a conductive polymer jacket (rather than an insulating polymer jacket).
- The conductive polymer jacket shall provide a moisture-proof barrier to protect the copper cable.
- The conductive polymer jacket shall be capable of continuously discharging a current of 50 mA per linear metre (15 mA per linear foot) of anode material for a minimum of twenty years.

Lead Wire

See Section 5.2.3.

Backfill

See Section 5.3.

Markings

The following shall be legibly marked with a weather-resistant marker on a tag attached to the anode:

- manufacturer
- anode model
- polymer type
- length (metres or feet)
- Company specification
- revision date

For example, "manufacturer", aaa, carbon impregnated polyethylene, 500m, TES-CP-MS (Cdn-US), 2012/10/01).

Shipping

Shipping specifications are as follows:

- As specified on the purchase order or Company standard drawings, continuous polymer anodes may be supplied bare (by itself) or prepackaged in a 38 mm (1½ inch) diameter flexible mesh tube.
- Prepackaged conductive polymer anodes shall contain a high-grade coke backfill conforming to Section 5.3. The conductive polymer anode shall be centered within the flexible mesh tube.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water, as directed by the supplier.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.1.6 Canister Anodes

Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass and dimensions are as follows:

- Only tubular anodes shall be placed in canisters. Anodes shall meet the requirements of Section 5.1.4 before assembly.
- The canisters shall be manufactured as follows:
  - spiral corrugated perforated galvanized steel – 28 gauge minimum
  - diameter – 225 to 235 mm (8 inches) minimum
  - length – anode length + 600 mm (2 feet)
  - plywood end caps – 16 mm (¾ inch) minimum thickness

Assembly

High silicon chromium anode assemblies shall be canistered as follows:

- With the bottom end cap in place, the anode shall be centered in the can and filled with coke, such that the anode has 200 mm (8 inches) of coke beyond each anode end.
- Calcined petroleum coke, as per Section 5.3, shall be mechanically compacted around the anode.
- An inner plywood cap shall be secured to the can immediately above the compacted calcined petroleum coke.
- A steel bolted eyelet shall be attached to the top inner plywood cap, and the lead wire shall exit through a close fitting hole to the side of center.
- The wire shall be coiled and placed on the inner cap.
- A top end cap, with access to the coiled wire, shall be attached to protect the coiled wire during shipping.

Refer to Company standard drawings.

Shipping

Shipping specifications are as follows:

- All canned anodes shall be securely attached to a pallet in such a manner to avoid damage to the anodes or canisters.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water, as directed by the supplier.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.1.7 Graphite Anodes

Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass and dimensions are as follows:

- The chemical composition for the graphite shall be GR060CP grade or equal.
- The graphite shall be treated with wax or resin, as specified on the purchase order.
- Center connections shall be tested to verify the connection falls below 0.004 ohms (4 milliohms).

Lead wire

See Section 5.2.2.

Backfill

See Section 5.3.

Shipping

Shipping specifications are as follows:

- Anodes shall be packaged in a manner to avoid breaking during shipment.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water.
- The anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.1.8 Mixed Metal Oxide Anodes – MMO Anodes

Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass, and dimensions are as follows:

- The chemical composition of titanium shall conform to ASTM B265.
- The anode rating per foot and length is as specified on the purchase order.

Lead wire

See Section 5.2.2.

Backfill

See Section 5.3.

Shipping

Shipping specifications are as follows:

- Anodes shall be packaged in a manner to avoid damage during shipment.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water.
- The anode wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.2 Cable

5.2.1 General

General specifications for cable are as follows:

- All cable shall be rated for use from -40°C to 60°C, or -40°F to 140°F.
- Cables shall have an underground rating.
- All cables shall conform to ASTM B3 and ASTM B8 or IEC 60228.
- All cables shall be rated to handle 600 V direct current.
- Unless specified, the cable size, cable length and cable colour shall be as indicated on the purchase order or Company standard drawings.
- The outer insulation layer shall be marked to include the manufacturer, conductor size and number of strands (e.g., “manufacturer,” AWG 4, 7/S).

5.2.2 Anode Lead Wire

Magnesium Anodes or Zinc Anodes

Specifications for magnesium anodes or zinc anodes are as follows:

- The anode lead wire shall be a continuous seven stranded, AWG 10 or larger (unless specified on the purchase order) annealed copper conductor, minimum 3 metres (10 feet) long. The insulation shall be blue for magnesium anodes and white for zinc, unless specified on the purchase order, to be consistent with site specific installations. The insulation shall be RWU90 cross-linked polyethylene (XLPE), or direct burial high molecular weight polyethylene (HMWPE).
- Lead wires shall be attached to the galvanized steel core by silver solder, and the connection shall be made moisture-proof by encapsulating the connection with an electrical sealing compound. The lead wire connection shall withstand a steady load pull of 200 kg (440 lbs) without separation from the anode.
- For zinc grounding cells, the lead wire shall be a continuous seven stranded, AWG 2 or larger annealed copper conductor, minimum 3 metres (10 feet) long. The insulation shall be white for zinc anodes. The insulation shall be RWU90 XLPE, or direct burial HMWPE. The wire shall be compression connected to the anode core and sealed with an electrical sealing compound.
- If magnesium anodes are to be used with solar panels, the cables shall meet the requirements of an impressed current system.

Tubular Anodes

Specifications for tubular anodes are as follows:

- For deep-well anode leads, see Deep Anode Lead Cable in Section 5.2.3.
- Unless otherwise specified, anode leads shall be AWG 8.
- The anode lead wire shall be a continuous conductor of AWG 8 with a seven-stranded copper conductor. The insulation shall be black, and shall consist of at least 2.78 mm (0.1 inch) of high molecular weight, medium density polyethylene that conforms to ASTM D 1248, Type II, Class C, Category 4, Grade J4E9.
- The use of lead (Pb) anchors for cable connections is not permissible.
- Attachment of the lead wire to the anode shall be made by a permanent compression connection. The lead wire connection shall be centered inside the anode.
- The anode lead wire shall be visually inspected before attaching the anchoring assembly, to ensure that none of the copper strands have been scored or scratched. Before applying the compression crimp connector, the copper strands of the lead wire shall be manually twisted into a compact spiral to facilitate even distribution of stress to each of the strands.
- The lead wire MDPE or HMWPE jacket surface shall be roughened for 50 mm (2 inches) anode end to improve adhesion to the sealant.

- The lead wire center connection to the anode shall be sealed using ArmorThane STS-200 Side A and Side B cured polyurethane, or approved equivalent. The sealant thicknesses shall be a minimum of 150 mm (6 inches) both above and below the center connection. The depths (millimetre or inches) of top and bottom epoxy seals shall be measured by probing and recorded directly on the outside of all anodes with a permanent marker. In addition, date and distributor name shall be marked with a permanent marker on the anode.
- The seller to the Company shall perform non-destructive random checks of sealant levels, as quality assurance that sealant levels marked on the outside of the anodes are correct. Records of quality assurance checks completed shall be sent to the Company before shipping. If any non-conformances are indicated, all other anodes having the same assembly date and manufacturer shall be inspected and repaired as necessary to meet this specification.
- The lead wire connection to the anchoring assembly shall be destructively tested before and at the end of each production day, to ensure compression equipment is operating satisfactorily. In addition, each anode shall be manually (i.e., by hand) pull tested by the technician after the mechanical connection to the anode is completed. Pull tests shall not be performed after sealant application.
- All anode leads shall be tested to ensure electrical continuity to the anode after sealant has cured and before shipping.
- Anode leads shall be attached in accordance with anode manufacturer's recommended mechanical procedures. The anode manufacturer shall provide a lead wire installation procedure to the anode supplier and Company. In case of conflict between this specification and manufacturer's recommended procedures, this specification shall apply.
- Attachment of the anode lead wire shall only be performed by previously approved distributors.

5.2.3 Other Cable

Negative Cable

Cables shall have stranded annealed copper wires. Insulation shall conform to NEMA WC70/ICEA S-96-658, have a minimum thickness of 2.78 mm (0.1 inch) and shall be high molecular weight, medium density polyethylene that conforms to either:

- ASTM D 1248, Type II, Class D, Category 4, Grade J4E9,
- ASTM D 1248, Type I, Class C, Category 5, Grade E5 and J1, or
- ASTM D 1248, Type I, Class A, Category 5, Grade E4 and E5

Minimum thickness of the HMWPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and a minimum of 18 strands for cable sizes larger than AWG 2.

Positive Cable

Cables shall have stranded annealed copper wires. Insulation shall conform to NEMA WC70/ICEA S-96-658, have a minimum thickness of 2.78 mm (0.1 inch) and shall be high molecular weight, medium density polyethylene that conforms to either:

- ASTM D 1248, Type II, Class C, Category 4, Grade J4E9,
- ASTM D 1248, Type I, Class C, Category 5, Grade E5 and J1, or
- ASTM D 1248, Type I, Class A, Category 5, Grade E4 and E5

The minimum thickness of the HMWPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and a minimum of 18 strands for cable sizes larger than AWG 2.

Cables shall have stranded annealed copper wires. Insulation shall conform to NEMA WC70/ICEA S-96-658, and shall be high molecular weight, medium density polyethylene that conforms to:

- ASTM D 1248 Type II, Class D, Category 4, Grade D6
- ASTM D 1248, Type I, Class C, Category 5, Grade E5
- J1 or ASTM D 1248, Type I, Class A, Category 5, Grade E4 and E5

The cable shall be tested for cold bend at -30°C (-22°F) and impact at -40°C (-40°F). Minimum thickness of the HMWPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and a minimum of 18 strands for cable sizes larger than AWG 2. The minimum thickness of the HMWPE shall be 4 mm (0.16 inch).

Note: Cable colour should be consistent with specific installation practices.

Alternatively, an additional 1.52 mm (0.06 mm) thick red PVC outer jacket shall be extruded over the 2.78 mm (0.1 inch) HMWPE black cable.

Armoured Cable

Single conductor armoured cable shall have stranded annealed copper wire. Insulation shall conform to NEMA WC70/ICEA S-96-658, have a minimum thickness of 2.78 mm (0.1 inch) and shall be high molecular weight, medium density polyethylene (HMW-MDPE) that conforms to ASTM D 1248, Type II, Class C, Category 4, Grade J4E9. Minimum thickness of the HMW-MDPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and 19 strands for cable sizes larger than AWG 2. The middle layer shall consist of aluminum armour.

Multiconductor armoured cable shall be Teck 90, conforming to CSA C22.2 No. 131, or an ASTM equivalent. The middle layer shall consist of aluminum armour.

Single Jacket Cable – Test Leads and Sacrificial Anodes

Single-jacket cable shall be stranded copper conductor in sizes not larger than AWG 6. Insulation shall be RWU-90 XLPE (-40°C/-40°F), with a thickness of 1.83 mm (5/64") and conform to CSA C22.2 No. 38, or an ASTM equivalent.

Deep Anode Lead Cable

To resist chemical attack, cable for deep anode bed applications shall be ethylene chlorotrifluoroethylene (ECTFE) fluoropolymer (HALAR or equivalent) jacketed.

Dual-extrusion HALAR cable shall have stranded annealed copper wires. Insulation shall be a homogenous wall of natural ECTFE fluoropolymer (HALAR or equivalent) extruded over the conductor. Insulation shall conform to NEMA WC70/ICEA S-96-658 and the outer insulation shall be high molecular weight polyethylene conforming to ASTM D 1248, Type 1, Class C, Category 5, Grades E5 and J1. Average thickness of the HALAR insulation shall be 0.5 mm (0.02 inches). Minimum thickness at any point shall be not less than 90% of the specified average thickness. Average outer jacket insulation thickness shall be 1.6 mm (0.06 inches). The minimum thickness shall be not less than 80% of the specified average thickness. The completed cable shall be tested in accordance with the requirements of NEMA WC70/ICEA S-96-658.

5.2.4 Summary

Table 5-1 provides a summary of the cable specifications.

Table 5-1: Summary Cable Specifications

Description	Insulation Description	Insulation Thickness (min mm)	Insulation Thickness (min inch)	Colours Specified
Armoured cable, AWG 2, 4	Inner: HMW-MDPE	2.78	7/64	N/A
	Middle: Aluminum armour	Standard	Standard	N/A
	Outer: Colored PVC	1.52	1/16	Per site specific construction drawings
AWG 2, 4 mainline positive cable (Option 1)	Inner: HMW-MDPE	2.78	7/64	Black
	Outer: Coloured PVC	1.52	1/16	Red
AWG 2, 4 mainline positive cable (Option 2)	HMW-MDPE	4.00	5/32	Red
AWG 2, 4 Alberta positive cable	HMW-MDPE	2.78	7/64	Black
AWG 4 negative cable	HMW-MDPE	2.78	7/64	White
Single jacket cable AWG 6	RWU-90 XLPE (-40°C/-40°F)	1.83	5/64	Per site specific construction drawings
Single jacket cable AWG 8	RWU-90 XLPE (-40°C/-40°F)	1.83	5/64	Per site specific construction drawings

Table 5-1: Summary Cable Specifications (Cont'd)

Description	Insulation Description	Insulation Thickness (min mm)	Insulation Thickness (min inch)	Colours Specified
Single jacket cable AWG 10, 12	RWU-90 XLPE (-40°C/-40°F)	1.83	5/64	Per site specific construction drawings
Dual extrusion (HALAR or approved equivalent)	Inner: ECTFE fluoropolymer	0.5	2/100	Per site specific construction drawings
	Outer: ASTM D 1248 (colored)	1.6	1/16	Per site specific construction drawings
No. 2 ACSR	N/A	N/A	N/A	Per site specific construction drawings

For shipping, all cables (i.e., anode lead wires, cable spools and test station wires) shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.2.5 Splice Kits

Splice kit specifications are as follows:

- Epoxy splice kits shall contain a plastic mold, which completely surrounds the crimped cable connection and seals the cables such that the epoxy does not leak out during the cure time. Kits shall contain tape to seal the points at which the cables enter the plastic mold. Epoxy mixture shall cure in 30 minutes at temperatures of 15°C (60°F) and above. Kits shall also be rated up to 1000 volts.
- Heat shrink splice kits shall contain, as a minimum, an adhesive coated polyethylene sleeve, mastic filler and black cloth tape, or a Company approved equivalent. The sleeve shall extend 50 mm (2 inches) beyond each end of the connection. Refer to Company standard drawings.
- For splicing and sealing of continuous polymer anodes, only end caps, splice kits and tees that are approved by the conductive polymer anode manufacturer shall be used.

5.2.6 DC Poleline and Cables

DC poleline and cable specifications are as follows:

- The poles shall be minimum 12.2 metres (40 feet) long, Class 5, with Penta #8 retention, or CCA-peg treatment.
- The conductor shall be No. 2 ACSR cable, unless specified otherwise.
- Rock anchors for the poles shall be Tri-Anchor Line Pole Rock Anchor type 8-18-28.
- All pole line hardware shall be galvanized according to Ontario Hydro Electrical Safety Code, Section 75, or equivalent.

- Guy wires shall be stranded steel. The wires shall be galvanized and have a diameter of 9 mm minimum. Guy guards are required at all installed locations. Guy guards are to be made of plastic, and provide visual identification for public safety. The guards shall be secure to the guy wire using the manufacturer's supplied hardware.
- Insulators shall be selected in accordance with Ontario Hydro Specifications 31, 32, 33, or Table 100 or equivalent.

5.3 Coke and Other Backfill

5.3.1 General

All coke supplied shall be calcined, and all coke tests shall be conducted as per the referenced test methods.

5.3.2 Chemistry

The composition and tests methods are based on dry weight, and are outlined in Table 5-2.

Table 5-2: Test Methods and Coke Composition

Category	Test Method	Shallow Anodes	Deep Anodes	Continuous Polymer Anodes
Carbon (fixed)	ASTM D3172 or D5142	98.7% minimum	99.2% minimum	99.2% minimum
Ash	ASTM D3174 or D5142	0.60% maximum	0.60% maximum	0.60% maximum
Sulfur	ASTM D4239	6% maximum	6% maximum	6% maximum
Moisture	ASTM D3173 or D5142	0.20% maximum	0.20% maximum	0.20% maximum
Hydrogen	ASTM D5373 (ultimate analysis for hydrogen content)	0.10% maximum	0.10% maximum	0.10% maximum

5.3.3 Other Requirements

Coke for deep anodes and continuous polymer anodes shall be dust-free. No de-dusting oils shall be used in the manufacture of the calcined coke.

Coke shall meet or exceed the requirements outlined in Table 5-3.

Table 5-3: Other Requirements for Coke

Category	Test Method	Shallow Anodes	Deep Anodes	Continuous Polymer Anodes
Bulk density	Modified ASTM D4292	≥975 kg/m3	≥1,100 kg/m3	≥1,100 kg/m3
Resistivity	carbon industry test C12A @ 150 psi (dry basis)	<0.2 Ωcm	<0.2 Ωcm	<0.2 Ωcm
Particle size	ASTM D293 or ASTM D4749	#4 Mesh - 95% #200 Mesh - 5%	#12 mesh -100% #200 mesh - 5%	#12 mesh - 100% #200 mesh - 5%

Note: Particle size is listed as a percentage of coke passing through the screen.

For deep and continuous anode installations, Loresco SC-3 Coke Breeze, TC-Alcoke/Z0637 Coke Breeze and Asbury 251-P Coke Breeze, or a Company-approved equivalent are acceptable.

For shallow anode installations, Loresco DW-1 Coke Breeze, TC-Alcoke/Z0637, or a Company approved equivalent are acceptable.

The coke breeze supplier shall provide the Company with a "Certificate of Analysis" for each batch or lot (as specified by manufacturer) of coke breeze indicating that the coke breeze meets Company specifications.

5.3.4 Conductive Carbon Grout

Conductive carbon grout specifications follow:

- In areas where the current discharge zone could lead to the interchange flow between water-bearing formations, conductive carbon grout shall be used in the annular to form a conductive seal.
- The mixture of grout and round-grain calcined petroleum coke particles shall have additional additives to minimize the apparent viscosity of the slurry.
- The coke particles shall meet the minimum coke requirements listed above.

5.3.5 Other Backfill

The anode shall be centered in the backfill.

Backfill surrounding magnesium anodes shall have the following composition and properties:

- Gypsum – 75 to 80%
- Bentonite – 15 to 20%
- Sodium sulphate – 0 to 5%

Backfill surrounding the zinc grounding cells shall have the following composition and properties:

- Gypsum – 80 to 85%
- Bentonite – 15 to 20%
- Sodium sulphate – 0 to 5%

5.3.6 Shipping

All backfill shall be wrapped in weather and water tight UV-resistant plastic. All backfill packaging shall be clearly labelled with material designations, as specified in Sections 5.3.3, 5.3.4, and 5.3.5.

5.4 Deep Anode Venting

Deep-anode venting specifications are as follows:

- Shall allow for venting of gases a full 360-degree of the vent pipe without a loss of pipe strength.
- Vertical slits are preferred, and shall be 3.8 cm (1½ inches) in length, or greater, and shall be 0.015 cm (1/64 inch) in width.
- The diameter of piping shall be 25.4 mm (1 inch) inside diameter and 32.3 mm (1¼ inches) outside diameter.
- Material shall be non-conducting and resistant to chlorine attack, if chlorine is a possibility.
- Lengths of pipe joints shall be in either 3 metres (10 feet) or 6 metres (20 feet) lengths.
- If plowing is used, vent piping from a deep well to a vent termination point shall be 1 inch non-perforated coiled HDPE pipe. The minimum outside diameter of HDPE pipe shall be 33.4 mm (1.3 inches) and the minimum wall thickness shall be 3.02 mm (0.1 inches).

5.5 Isolation Sets

5.5.1 Flange Isolating Kit

Flange isolating kit specifications are as follows:

- These devices shall be pressure rated for the intended use, as shown on the Company standard drawing.
- Component dimensions shall conform to ANSI B16.21, Type F.
- Washers shall be zinc-plated steel.
- Retainers and double washers shall be glass reinforced epoxy (G10).
- Viton or Teflon shall be used as the sealing element.
- Minlon or Mylar insulation sleeves shall be used with insulation sets.

5.5.2 Monolithic Isolators

Monolithic isolator specifications are as follows:

- Metal components (excluding pipe-end pups) shall be forged steel.
- Pipe-end pups shall conform to the requirements for each installation, as specified on the purchase order or Company standard drawings.
- "Stiff" electrical isolating components shall consist of glass-reinforced epoxy composite conforming to ASTM D709, Type IV, Group G.10 requirements (G.11 is an acceptable alternative).
- Elastomeric sealing elements shall consist of nitrile butadiene rubber, conforming to ASTM D2000.
- Insulating filler materials shall consist of solventless epoxy resin.

- Adhesive sealant elastomeric materials shall be silicon.
- Each device shall be tested as follows:
  - Electrical test – each monolithic isolator shall be tested according to the requirements of the IEC 60-1 and 60-2
  - DC resistance test – each isolator shall maintain a resistance of at least 5 MΩ for one minute at an applied stress of 1000 VDC
  - AC resistance test – each isolator shall maintain a resistance of at least 1 MΩ for one minute at an applied stress of 5000 VAC (50-60Hz)

5.5.3 Isolating Unions

Isolating union specifications are as follows:

- Metal components shall be forged steel.
- Insulated against galvanic corrosion.
- Tailpiece coated with a tough baked industrial thermo-setting epoxy, bonded directly to the metal.
- Teflon shoulder gasket for extra wear resistance
- Insulating properties – exceeds 500 volts dielectric resistance

5.6 Rectifiers

5.6.1 General Information

General specifications for rectifiers are as follows:

- Rectifiers shall be designed to operate continuously at temperatures between -40°C and 50°C (-40°F and 122°F).
- The DC voltage output shall be fully isolated from the line voltage.
- Rectifiers shall have a primary and secondary arrestor designed to protect against electrical transients caused by lightning, induction and switching surges.
- Output ratings shall be as specified on the purchase order and Company standard drawings.
- The AC input of all rectifiers shall be single phase, 60 Hz, AC 230V, or as specified on the purchase order and Company standard drawings.
- The AC input lugs are to be sized to accommodate an AWG 2 and to provide a "dead front" for connection to the AC line.
- All rectifiers are to be equipped with an AC 115V, 15A, 3-pin ground fault interrupt (GFI) service receptacle. This receptacle is to be connected between the hot and the neutral through a fully magnetic circuit breaker from the line side of the rectifier's main circuit breaker. This receptacle is to be mounted on the front of the panel for easy access.
- Rectifying elements shall be silicon solid state and derated to 50% of the manufacturer's current rating at 100°C (212°F). Silicon diodes shall be constructed into a single-phase full wave bridge configuration. Heat sinks shall be sized to keep diode junction and core temperatures from exceeding 100°C (212°F) in 45°C (113°F) ambient conditions. Diodes shall have a minimum peak inverse voltage (PIV) of 800 V. Where applicable, clear chromate finish aluminum heat sinks (per MIL-C-5541) are acceptable. NOTE: ROHS (Restrictions of Hazardous Substances) disallows anodizing due to use of sulphuric and chromic acids.

- All cables, including jacket materials, shall be suitable for handling, and shall be rated to operate continuously over a temperature range -40°C to +105°C (-40°F to 220°F) ambient air temperature. Alternatively, all cables shall have the insulated jacket coatings de-rated according to applicable electrical codes or standards (Canadian and US) to satisfy the ambient air-temperature operating range.

5.6.2 Enclosure

Enclosure specifications are as follows:

- Enclosures for air-cooled cathodic protection rectifiers shall be constructed to CSA Enclosure 3R Classification, as required by CSA C22.2, No. 107.1 or NEMA MR 20 and NEMA MR 250. The rectifier case shall be NEMA 3R, and completely weatherproof for outdoor use.
- Minimum sheet metal thickness shall be 12 gauge wiped coat mill galvanized steel, as per ASTM 123 and, when practical, the cabinet shall be equipped with a slide-out chassis. Enclosures shall be vented for natural air convection and screened against insects. Screens shall be reinforced to provide structural integrity to the rectifier cabinet. Screens over openings shall meet the requirements set forth by CSA C22. No. 107.1. Hinges and enclosure assembly bolts shall be of stainless steel.
- Enclosures shall be painted white (or as otherwise specified), with the Company rectifier number or identifier in 50 mm to 75 mm (2 inches to 3 inches) black lettering on the outside of the front cabinet door and equipped with a pad lockable draw latch, consisting of a heavy-duty, single-hasp draw latch.
- Either a pole-mounting bracket or legs on the bottom (minimum length 600 mm [24 inches]) so it can be platform mounted, shall be provided and will be specified on the purchase order.
- Electrical panels shall be minimum thickness of 4.7 mm of (0.2 inches) NEMA Grade 'XX' phenolic. For panels greater than 100A, NEMA Grade 'UTR' type shall be used.
- All electrical hardware shall be copper, or brass finished in electroless nickel plate. All connections shall be made secure with lockwashers and nuts torqued in accordance with manufacturer's recommendations.
- For all rectifiers, a flush-mount outdoor wall plate (Leviton part #4925-2) is to be installed and if possible it is to be located on the bottom of the rectifier cabinet adjacent the closest side, or back wall, of the rectifier cabinet nearest the low voltage interruption plug and adjacent to the 200 mm x 250 mm x 150 mm (10 inches x 10 inches x 6 inches) equipment bay. The access port shall have a hinged and environmentally sealed cover. The cover hinge shall also be spring loaded for closure.
- The enclosure shall have the appropriate dimensions to accommodate an empty space for other equipment. The equipment bay is to be located on the bottom of the rectifier, adjacent to the access port described in the previous bullet. The free and clear dimensions of the equipment bay are to be 250 mm x 250 mm x 150 mm (10 inches x 10 inches x 6 inches). The equipment bay dimensions do not include the volume taken by the access port.

5.6.3 Transformer and Efficiency Filter Construction

Transformer and efficiency filter construction specifications are as follows:

- The transformer is to be designed as full isolation with separate and isolated primary and secondary windings, with a minimum efficiency of 95% at the maximum-rated voltage output.
- Transformer magnet wire and insulation materials are to be rated for CEC Class H (180°C) or NEC Class F (355°F), as applicable. Insulating materials shall be dipped in a thermosetting varnish and baked. Varnish shall meet or exceed the CSA requirements for Class H or NEC requirements for Class F operations, as applicable. Transformer voltage regulation shall not exceed 3% from full-rated load to no load.
- Dielectric strength of all insulating materials shall not be less than 2000 V RMS, as tested for one minute when applied between windings and the transformer core.
- The transformer shall be equipped with a minimum of 25 tap bar steps of secondary voltage adjustment (five coarse and five fine).
- Rectifier input overload and short-circuit protection shall be accomplished by magnetic circuit breakers; one pole per input line of AC power. Circuit breakers must trip at 140% of the rated AC input capacity of the rectifier. The input shall be labelled.
- Rectifier output over-load and short circuit protection shall be achieved by rectifier fuses in the transformer secondary of the rectifier. Rectifier fuses shall be sized for 120% rated transformer secondary RMS current. The output shall be labelled. (When the secondary fusing requirement exceeds 90 amps AC, the electronic Fuse Replacement Module will be considered as an acceptable alternative).
- Where specified, an efficiency filter (choke) shall be provided in the negative output of the rectifier. In the case of a multi-circuit rectifier, each circuit shall be provided with a choke, as mentioned. The choke shall be connected between the stack negative and the negative bus.

5.6.4 Instrumentation

Instrumentation specifications are as follows:

- The rectifier shall be equipped with multi-position switch(s) to connect a digital ammeter and voltmeter into each rectifier circuit, or pipeline negative lead. In addition, the multi-position switch shall have an "off" position that leaves the meter disconnected. The multi-position switch will also have a "lines" position, which activates a second switch that will connect each pipeline into the digital ammeter. In other words, two eight position rotary switches with the following settings:
  - Primary rotary switch – "Off, Circuit 1, Circuit 2, Circuit 3, Circuit 4, Circuit 5, Circuit 6 and Line" labels
  - Secondary line rotary switch – "Line 1, Line 2, Line 3, Line 4, Line 5, Line 6, Line 7, Bond" labels

  This represents a case for a six-circuit rectifier connected to seven pipelines and one bond. Switch types and configurations may be varied according to the number of rectifier circuits, pipelines or bonds that must be metered. The off position for the primary switch shall isolate the ammeter and the voltmeter from any internal and external signal sources.

- The ammeter and voltmeter panel displays shall be high-intensity light emitting diode (LED) displays, with a minimum 13.2 mm (0.52 inch) digit height. All metered readings shall maintain a displayed measurement accuracy to one decimal place (i.e., 0.1 Volts or 0.1 A). The ammeter shall have a minimum 3.5 digit display, and the voltmeter shall have a minimum 4 digit or 4.5 digit display. Both metres shall be auto zeroing and auto calibrating, during the manufacturer's initial setup. The required nominal voltage measurement range for the ammeter is ±199.9 mV (with the display scaled to the shunt ratings), and for the voltmeter it is ±199.9 volts (displayed as measured).
- Both the ammeter and voltmeter shall have an accuracy of ±0.10% (or two counts) at 25°C (77°F). The drift in measurement accuracy shall not exceed ±0.50% at a temperature of -40°C (40°F). Test data documenting the accuracy of both the ammeter and the voltmeter over a -40 to +80 °C (40°F to175°F) temperature range shall be provided to verify the accuracy criteria outlined above. The Company shall approve the digital ammeters and voltmeters before purchase.
- The power supply for the high-intensity LED ammeter and voltmeter shall have a dedicated on/off switch, and a protective fuse installed downstream of the AC input surge arrestor for the rectifier.
- The 50A/50 mV metering shunts shall be the panel-mounted Holloway type 'SW' style, with an accuracy of ±0.25%, where output currents are less than or equal to 50 A DC on any structure or rectifier circuit being measured. The Mobiltex or manufacturer of other existing remote monitoring units (RMUs) can measure shunt voltages ± 158 mV. Where currents to be measured exceed 50 A DC, the provisions two bullet points below shall be used. For the digital ammeter, the following shunt sizes are compatible with the ammeter: 50 A/50 mV, 100 A/100 mV and 200 A/200 mV.
- Where line return currents or individual rectifier circuit outputs are less than, or equal to, 50 A DC, the shunts shall be 50 mV and sized for the maximum rectifier output current for negative drains, and shall be installed in each "line" negative output of the rectifier, including bonds. A separate 50 mV shunt, also sized for the maximum rectifier (single circuit) or circuit output (multi-circuit units) current shall be placed to provide metering for each different circuit's output. The shunt voltage shall be a negative common mode voltage for compatibility with the RMU.
- Where line return currents or individual rectifier circuit output currents exceed 50 A DC, two shunts shall be installed in series on each rectifier circuit or line return exceeding the 50 A DC limit. The first shunt installed shall be a 50 mV shunt, sized as previously outlined in this section, and shall be dedicated to the sense leads for the RMU pre-wire. A second shunt shall be installed downstream of the first, with a rating such that a minimum of 1 mV of voltage drop occurs across the shunt for each 1 A of current (i.e., 100 mV – 100 A shunt) to be measured by the high intensity LED digital ammeter.

5.6.5 Terminals

Negative Output Terminals

When specified, all rectifier negatives, including those for multi-rectifier units, shall be bused together using removable shorting bars. The bars shall be placed after the choke (where applicable) on the negative side of the negative meter shunts on each circuit, and fed to one set of output terminals (lugs). The output terminals are to be labeled "Line 1", "Line 2", etc. Output terminal lugs are to be sized to accommodate up to an AWG 1/0, unless otherwise specified.

Positive Output Terminals

Separate positive output terminals are to be provided with each circuit, and are to be labelled. The output terminal lugs are to be sized to accommodate up to an AWG 1/0, unless otherwise specified.

Bond Terminals

Terminals labeled "bonds" shall always be provided as specified on the purchase order or Company standard drawings. Bond terminals are to be directly connected to the negative bus. Shunts for bond connections shall also be provided, if indicated on the purchase order or Company standard drawings. Bond terminal lugs are to be sized to accommodate an AWG 1/0, unless otherwise specified.

Remote Monitoring Unit (RMU) Pre-Wire

RMU pre-wire specifications are as follows:

- Optional, based upon site-specific requirements.
- All rectifiers requiring remote monitoring shall be pre-wired with sense cabling connected to a termination block
- Current measurement shunts (50 mV) for each rectifier circuit shall be located on the return side of each rectifier circuit to provide a negative common-mode voltage with the drain terminals. Sense cables shall be installed across each 50 mV shunt installed on the negative return for each rectifier circuit and negative line drains. These sense cables shall be labelled and terminated.
- As specified by the Company, voltage dividers shall be provided on sense cabling for each rectifier circuit to meet the specifications in Table 5-4.

Table 5-4: Voltage Divider Specifications

Rectifier Circuit Rating	Scaling Factor	RMU Metered Voltage into Pre-Wired Terminal Block
>150 Volts	10 : 1	0 – 20 Volts
0 – 150 Volts	1 : 1	0 – 150 Volts

- These dividers shall be installed in conjunction with the standard RMU pre-wire, as specified by Company. If no voltage dividers are called for, then the sense cables are to carry rectifier circuit line voltages, and are to be terminated.

- Sense cables shall be provided for all bonds to foreign structures, to measure both the bond current and the pipe-to-soil voltage on the foreign structure. In addition, the bond measurement facilities must ensure compatibility with the RMU. The channels allocated for measurement of bond currents and voltages shall have an option provided for full electrical isolation.
- This option is to be provided, as specified by the Company. If no electrical isolation devices are specified, then an empty terminal is to be left for the foreign structure sense lead (non-current carrying) and leave a blank terminal for a fixed reference cell lead. The 50 mV foreign structure current measurement shunt(s) shall be installed in series with the current carrying bond lead, and shall have sense leads terminated.
- Sense cables allocated to fixed reference cells must also ensure compatibility with the RMU.
- All sense cables shall be AWG 12 in size and have jacket materials compatible with the operation within the environment inside the rectifier cabinet. The sense cables, including jacket materials, shall be suitable for handling over a temperature range -40°C to 105°C (-40°F to 220°F) ambient air temperature. A control transformer shall be installed in each rectifier unit for future power for the RMU5 remote monitoring device.

Low-Voltage Interruption Terminal

Low-voltage interruption terminal specifications are as follows:

- All rectifiers shall be wired with a CONXALL 4282-5SG-300 (including 4295 dust cap) 5-pin female connector. The wiring associated with the plug shall be AWG 20 TEW stranded copper cable rated to operate up to 105°C (220°F) temperature. Wire terminations for the connector are to be made as per Section 5.6.9.
- The CONXALL 4282-5SG-300 5-pin female connector shall be installed on the rectifier's front phenolic panel to allow the 4295 dust cap to have a minimum clearance of 51 mm (2") from the rectifier cabinet door.
- The AC interruption relays shown in Table 5-5 shall be installed in parallel with the high-voltage twist-lock hubble connector across the interruption switch located on the L1 leg of the AC power supply wiring downstream of the AC surge suppressor (See Section 5.6.9).

Table 5-5: AC Interruption Relays

Rectifier AC Power Input Rating	AC Relays Types	AC Relay Model Numbers
0 – 50 A	Crydom Series 1	Model D2450-10
>50 A	Crydom Series 1	Model D24110-10

- All AC relays shall be installed with heat sinks appropriately sized to facilitate continuous operation of the AC relay under interruption.
- A Hammond BD2E 12 volt power supply transformer is to be installed to power terminals four and five on the CONXALL 4282-5SG-300 5-pin female connector. The input leads on the transformer are to be wired into the L1 AC supply lead, downstream of the AC surge suppressor, and the second lead is to be wired into the AC neutral (see Section 5.6.9).

- The wiring for the CONXALL 4282-5SG-300 5-pin female connector and the Crydom relays, as outlined previously in this section, shall be compatible with the Mobiltex CorrTalk Portable Interrupter Model SPI-1A, SESCO GPS timing device model TCMAD1-100, or SESCO GPS current interrupter model TCFAD1-100 in synchronously actuating the relays with respect to pre-set GPS time-based interruption intervals.

5.6.6 Lightning Protection

Lighting protection specifications are as follows:

- Unless otherwise specified, metal oxide varistor arrestors shall be installed on both the AC input and the DC output of the rectifier.
- An arrestor shall be placed between the chassis and DC positive of each circuit, DC negative of each circuit and the chassis ground.
- Where semi-conductor or valve type arrestors are used, they are to be in an accessible location and enclosed in a small metal enclosure. The enclosure is to prevent fire in the event of a fault or surge.
- Arrestors are not to be mounted on the front control panel.

5.6.7 Inspection and Testing

Testing

All units shall be subjected to tests that verify that specifications are met. Documentation of these tests shall be provided.

Dielectric Strength Tests

Dielectric strength-test specifications are as follows:

- Every transformer shall be subjected to dielectric strength tests, conducted as per CSA C22.2 No. 107.1, or UL 60950, or NFPA 70 as applicable.
- Dielectric strength tests shall be conducted on the transformer before varnish dipping and baking, and after baking. The after baking test can be included as part of the final rectifier dielectric test.
- All assembled rectifiers shall be subjected to dielectric strength tests, as outlined in CSA C22.2 No. 107.1, or UL 60950, or NFPA 70 as applicable.

Inspection

After assembly, the rectifier shall be subjected to inspection of all wiring and mechanical components and their connections. Inspection shall also include over-all workmanship.

Operation

Rectifiers shall be subjected to testing and recording of all rectifier electrical parameters as follows:

- AC input voltage, current, apparent power and true power
- DC output voltage, current and power
- AC power factor
- AC to DC conversion efficiency

If a filter is required, the ripple at full output voltage shall be measured and documented.

Rectifier metres shall be tested to meet the requirements specified in Section 5.7.4.

5.6.8 Shipping

A rectifier identification plate shall be firmly attached on the inside of the cabinet door, and shall contain the following:

- Manufacturer's name and code number
- AC volts and amperes
- line frequency
- number of phases
- DC voltage and ampere ratings
- ambient temperature rating
- serial number
- CSA file number (as applicable)

The following items are to be in a waterproof enclosure with documentation in the rectifier door, or if specified, label using lamacoid plates, or an equivalent approved by Company cathodic protection engineering personnel. Labels are to have a black background and white lettering.

- AC rectifier input terminals
- transformer tap positions (coarse & fine)
- negative and positive output lugs
- all metres
- Switch positions
- main breaker
- DC and AC arrestors
- all fuses (size and type)
- interrupter mode switch
- interrupter receptacle
- utility receptacle
- high voltage (if applicable)

A circuit diagram and parts list shall be included with each rectifier. The rectifier drawing shall be laminated and mounted on the inside of the front door of the rectifier. In addition, a paper copy of the rectifier electrical schematic and a parts list for each rectifier detailing all of the components shall be provided to Company Cathodic Protection Engineering personnel.

Each rectifier shall be individually packaged for shipment, and shall have the rectifier name or rectifier number clearly labelled on the exterior of the shipping box.

5.6.9 Rectifier Circuit Diagram

Refer to the Company standard drawings, or as per the Company's instruction.

5.7 Thermoelectric Generators

5.7.1 General Information

General specifications for thermoelectric generators are as follows:

- TEGs shall be designed to operate at temperatures between -45°C and 65°C (-50°F and 150°F).
- TEGs shall be designed to operate in unlimited rain or snowfall, provided that the unit is not flooded.
- TEGs shall operate in 100% relative humidity.
- TEGs shall operate in wind gusts of up to 140 km/hr (85 mph).
- TEGs shall come complete with automatic re-ignition.
- All components shall be manufactured in modules, or assemblies for easy field maintenance.
- As necessary, the units shall be furnished with over-temperature protection circuitry.

5.7.2 Enclosure

Enclosure specifications are as follows:

- Enclosures shall be designed for outdoor installation, and be of stainless steel and aluminum construction.
- Enclosures shall be equipped with pad-lockable latches.
- All electrical hardware shall be copper, or brass finished in electrolysis nickel plate. All connections shall be made secure with lockwashers and nuts, or with compression-type terminals.
- Enclosures shall be identified with the Company's rectifier number, or identifier in 50.8 mm to 76.2 mm (2 inch to 3 inch) black lettering on the outside of the front cabinet.

5.7.3 Mechanical Construction

Mechanical construction specifications are as follows:

- Units shall have a lead telluride solid-state, hermetically sealed power unit.
- Units shall have a nickel-alloy construction, meeker-type burner design that is stable in normal operating conditions.
- The individual TEG(s) shall be ordered to operate on butane, propane or natural gas, depending on the available fuel supply.

5.7.4 Metering and Instrumentation

Metering and instrumentation specifications are as follows:

- A separate suitably scaled voltmeter and ammeter as well as a current measuring shunt shall be provided to measure the DC output.
- Metres shall be a minimum 90 mm (3½ inches) size, with a minimum scale length of 73 mm (2⅞ inches).
- Metering accuracy shall be ±2% of full-scale deflection at 25°C (77°F). Temperature compensation shall be no more than 0.85% per 10°C (50°F), for temperatures other than 25°C (77°F).
- The package shall contain a terminal block capable of accepting 2/0 AWG (9 mm or ⅜ inch) cable.
- The package shall contain a variable resistor designed to control current output.
- Electrical output isolation from the chassis shall be achieved such that the leakage current does not exceed 100 mA.

5.7.5 Inspection and Testing during Manufacture

Inspection and testing specifications during manufacturing are as follows:

- All units shall be subjected to testing at 100% of rating.
- All units shall be subjected to tests as outlined in SPE-1000-94 for dielectric strength, bonding continuity, leakage current, stability and temperature.
- All units shall be subjected to testing and recording of all performance parameters as follows:
  - DC output voltage, current and power
  - DC input voltage, current and power
  - fuel pressure for rated power
  - set up voltage for rated power
  - leak test of fuel system
  - verification of ignition system operation

5.7.6 Shipping

An identification plate shall be firmly attached on the inside of the cabinet door, and shall contain the following:

- Manufacturer's name and code number
- serial number
- fuel usage
- fuel pressure setting

5.8 Solar-Power Units

5.8.1 General Information

General specifications for solar-power units are as follows:

- Solar-power units shall be as specified on the purchase order.
- The number of solar panels to deliver the requirements as specified in the purchase order, or Company standard drawings, shall be determined by the manufacturer or distributor.
- The size of the units (typically 12V DC or 24V DC) shall be specified on the purchase order or Company standard drawings.
- All solar-power units shall have a main disconnect switch between the solar panels and the controller.
- All solar-power units are to be supplied with a silicon oxide varistor lightning arrestor with:
    - clamp voltage 100 V
    - maximum operating voltage 48V DC
    - maximum current 50 kA
    - maximum energy 750 Joules (0.7 BTU)
    - unlimited number of surges
    - 10 nanosecond response time

  They are also to be supplied with a system electrical groundlug.

5.8.2 Panels

Panel specifications are as follows:

- Solar panels shall be mounted on 12 metres (40 feet) of Class 6 wooden utility poles.
- The diameter of the pole at the panel-mounting location is to be approximately 200 mm (8 inches).
- Mounting brackets to secure the solar panels shall be sized to accommodate attachment to the highest point on the utility pole.

5.8.3 Controllers

Controller specifications are as follows:

- Controllers shall be sized to accommodate the voltage and the current requirements as specified on the purchase order or Company standard drawings.
- Controllers shall have a continuous voltage and current display.
- Controllers shall be housed in a watertight enclosure with securable locking latches or handle.

5.8.4 Batteries

Battery specifications are as follows:

- All units shall be supplied with either absorbed glass mat (AGM) or gel-sealed batteries, as specified on the purchase order. The self-discharge rate of the battery must be less than 2% per month, and must have a 12-month warranty.
- Battery quantities and sizes shall be to provide a minimum of 72 hours autonomy, with no more than 50% depth of discharge.
- Batteries shall be housed in a separate insulated and vented battery box.
- The battery box is to have securable locking latches or handles. The battery box is to have mounting lugs to secure the box to a wooden platform, or platform approved by Company Cathodic Protection Engineering personnel.

5.8.5 Enclosure

Enclosed specifications are as follows:

- Power center enclosures must be rated as NEMA Type 3, 3R or 4, and are to be rain and sleet proof.
- The enclosures must have a drip shield over the door.
- The hinged door is to be sealed with seamless poured urethane gasket, and come complete with a lockable latching mechanism that maintain constant pressure on the gasket.
- The battery box shall be insulated with 50 mm (2 inch) high-density foam and sized to allow a 10 mm (½ inch) battery separation and be complete with a hinged lid with a lockable latch.

5.8.6 Shipping

The location to which the units are to be shipped shall be clearly marked.

5.9 Test Stations

The test lead assembly shall be as per Company standard drawings.

5.10 Remote Monitoring Equipment

5.10.1 General Information

General specifications for remote monitoring equipment are as follows:

- All RMUs shall be CSA certified, or UL approved.
- All units shall have flash program memory.
- Internal components shall operate in the temperature range -40°C to +80°C (-40°F to +175°F).

5.10.2 Enclosures

Enclosure specifications are as follows:

- Enclosures for RMUs shall be NEMA 4X rated fiberglass or polycarbonate.
- Enclosures shall be equipped with a pad-lockable draw latch.

- All units to be fitted with a CSA or UL approved (as applicable) 10 watt heater and control thermostat to maintain the enclosure internal temperature within the radio's operating temperature range.
- Insulation shall be a "K" value suitable to allow a 10 watt heater to provide the required minimum temperature.
- Insulation to be rigid, foil backed non-hygroscopic and non-flammable to provide for a maintenance-free interior.
- Enclosure to have a mounting plate supported over the insulation, for mounting components.
- GPS antenna is to be mounted on the top of the enclosure and to be suitably sealed to prevent both the ingress of moisture and unnecessary heat loss.
- The external electronic temperature sensor shall be mounted off-centre on the bottom of the enclosure, and is to be suitably sealed to prevent both the ingress of moisture and unnecessary heat loss.

5.10.3 Channels

Channel specifications are as follows:

- All units to be equipped with 10 analog inputs and one interrupt drive output.
- All units shall have four isolated digital input points.
- All units shall have one internal (mounted on a PCB), and one external electronic temperature sensor.

5.10.4 Interruption

Interruption:

- Shall be a solid state AC interrupt relay, 25 A @ 280 VAC maximum
- Is to occur via GPS time receiver

5.10.5 Communication

IMARSAT communication is to be via Easy Track Communication/ GPS unit, with an operating temperature range of -30°C to +50°C (-22°F to 122°F).

5.10.6 Command Options

All units shall be able to indicate:

- AC "power fail" alarm. (Debounce timer set to 1 hour.)
- AC power restored. (Debounce timer set to 1 hour)
- DC power fail (DC current goes to zero, e.g. fuse fails, rectifier fails). (Debounce timer set to 1 hour.)
- Low battery (no time delay in sending this alarm)

5.10.7 Power Supply

Power shall consist of 120 VAC to 12 VDC supply for transceiver and electronics. (TEG version will be 24 VDC to 12 VDC.)

All units shall have a battery backup with charger and a low-voltage disconnect.

5.11 Junction Boxes and Terminal Boxes

5.11.1 Junction Boxes

Junction-box specifications are as follows:

- Junction box size and location shall be as per the purchase order or Company standard drawings.
- Junction box enclosures shall be cast aluminum, as per Wright Aluminum Ltd. specifications (Model# WAL-56 or Model# WAL-102).
- All junction-box enclosures shall have a high-voltage shield, and be mounted on 76 mm (3 inches) OD conduit(s), as per Company standard drawings.
- All junction boxes shall be constructed to CSA Enclosure 3R Classification, or equivalent.

5.11.2 Terminal Boxes

Terminal box specifications are as follows:

- Terminal box size and locations shall be as per the purchase order and Company standard drawings.
- Terminal boxes shall meet Hammond (Model 1418N4M8) or Bel (Model R363008) specifications.
- Terminal-box enclosures shall have a minimum sheet-metal thickness of 14 gauge.
- All steel terminal box enclosures shall be CEMA/NEMA 4 rated, and shall be powder coated (ASA61 grade polyester or ANSI/ASA61 grey baked recoatable enamel).
- Hinges and enclosure assembly bolts shall be stainless steel or aluminum. The enclosure shall be equipped with a latching device.
- All terminal box enclosures shall have a high-voltage shield, and be mounted on two 76 mm (3 inches) OD conduits as per Company standard drawings.

5.11.3 Panels

Junction box panels shall be a minimum thickness of 4.7 mm (0.2 inches) of NEMA grade 'XX' phenolic.

All electrical hardware shall be copper or brass, finished in electrolysis deposited nickel plate. All connections shall be made secure with lockwashers and nuts tightened to the manufacturer's recommended torque.

5.12 Copper–Copper Sulphate Reference Electrodes

Unless otherwise specified, all copper–copper sulphate reference electrodes shall be EDI Model UL - 30 Year LongLifeTM reference electrodes. Element type shall be a saturated gelled $Cu/CuSO_4$. The lead wire shall be AWG 14 or larger, 15 metres (45 feet) or greater in length, insulated in high molecular weight polyethylene, and rated for underground service.

Where specified, the CSCL copper–copper sulphate reference electrode shall be CPMP-2-50. The length of the cable shall be as per the site-specific construction drawings.

5.13 NovaProbes

NovaProbe specifications are as follows:

- Permanent NovaProbes are patented and only available from licensed manufacturers.
- Permanent NovaProbes shall measure the following parameters:
  - local soil resistivity
  - local soil pH
  - local oxidation reduction potential
  - "on" pipe-to-soil potential

5.14 Coupons

Coupons shall be either 9 cm^2 or 50 cm^2 (1.4 in^2 or 9 in^2). Coupon test stations shall comply with Company standard drawings.

5.15 Exothermic Welds and Bonds

5.15.1 Thermite Welds

Thermite weld specifications are as follows:

- Thermite welds shall be a #15 gram charge (green cap) maximum with F-33 powder, or approved equivalent.
- A copper sleeve shall be used for wire sizes smaller than AWG 8. The sleeve size shall correspond to cable size.

5.16 Silver Soldering

Silver soldering specifications are as follows:

- Use only 2% silver/98% tin soldier material with the appropriate flux.
- "Tin" the pipe and the conductor to be soldered.
- Heat the pipe and melt a solder puddle sufficient in size to attach the conductor.
- Test for adequate bond and neutralize the acid flux with base solution.

5.17 Mechanical Bonds

Mechanical bond specifications are as follows:

- Circumferential clamp(s) is to maintain residual tension after the tensioning device is withdrawn. The cable connection to a circumferential clamp must be achieved by welding, or bolting to the clamping device.
- Any connection to structures, other than a pipe, must be achieved using materials required in the CEC or the NEC (as applicable) for grounding connections.
- Specially designed alteration to an electrical LB (elbow, back opens) fitting and connected to a flange bolt may be used. The apparatus shall be constructed of rigid conduit from a point 450 mm below grade and up to the LB. The cable shall pass through the conduit and connect to a lug inside the LB fitting. The conduit must be equipped with an EYS sealed fitting at the point of emergence from the ground.
- An alternate to the rigid conduit and EYS fitting is to use a single conductor Teck cable connected to the LB fitting with a "liquid tight" transition fitting.

5.18 Controlled Interference Bonds

Control device in an interference bond circuit shall consist of an appropriately sized resistor, or rheostat, and a meter or shunt.

5.19 AC Mitigation, Surge Protection and DC Decoupling

5.19.1 General Information

General specifications for AC mitigation, surge protection and DC decoupling are as follows:

- Isolation surge protectors shall be designed to simultaneously provide DC isolation and AC continuity at cathodic protection isolator locations, plus meet environmental ratings outlined in NEMA 4X and hazardous classifications for NEC, CSA: Class 1, Division 1 & 2, Groups A,B,C, D.
- Typical applications include installation where the facilities are subject to AC coupling, AC faults, or lightning, or electrical switching transients. Under AC faults or lightning (short term transients) it is allowable for the device to temporarily conduct DC current.
- The device shall be designed to allow an unlimited number of switching operations (associated with occasional AC faults or lightning events) without failure.
- The ultimate failure mode of the device shall be in the closed-circuit position.
- The device shall be equipped with two hole (⅜ inch diameter) terminal pads for cable connection.
- Isolation surge protectors shall be solid-state devices capable of normal operation at ambient temperatures between -45°C and +45°C (-50°F and 113°F).

5.19.2 Polarization Cell Replacements – Electronic Device Performance Characteristics

The performance characteristics shall be specified by the following product ratings.

- lightning surge current
- voltage threshold
- 60 Hz fault current
- 60 Hz steady-state current
- enclosure
- instrument test feature
- special requirements

If not specified on the purchase order, the following parameters shall apply:

- Lightning surge current – 50 kA: This parameter specifies the maximum current that the device must be capable of passing while holding the voltage across the terminals below 700 volts. The test waveform shall be 8 X 20uS.
- DC blocking voltage – 4.5 volts: This parameter specifies the upper DC voltage level, which will be blocked by the device while continuously conducting 60 Hz AC current.
- AC fault current at 60Hz – 50 kA for 1 cycle: This parameter specifies the minimum AC fault current that the device must be capable of passing without failure.

- Steady-state AC current at 60 Hz – 50 A RMS: This parameter specifies the maximum allowable steady state AC current that can be passed through the device while maintaining DC isolation.
- AC voltage drop under fault at 60 Hz – 35 volts AC: This parameter specifies the maximum AC voltage drop through the device under full rated fault current.

5.19.3 Enclosure

Enclosure specifications are as follows:

- Unless otherwise specified, the device shall be furnished with a NEXA 4X metallic enclosure suitable for all or channel mount, complete with a padlockable access cover.
- The device shall be marked with the manufacturer's name, the device model number and the device serial number.

5.19.4 Instrumentation

The device shall contain a sufficient number and type of test terminals to allow AC and DC voltage and current measurements while in operation. All test terminals shall incorporate a dead-front design to prevent personnel shock, and shall be clearly labelled.

5.19.5 Shipping

The device shall be packaged for shipping in order to prevent damage.

6 QUALITY MANAGEMENT

6.1 Quality Checks and Documentation

The Company requires the following reviews before and during work:

- Review that the manufacturer is approved within the Company's approved vendor list
- Review the materials adhere to the guidelines set forth in this specification

The Company requires the following documentation before work starts:

- Verification of equipment calibration, as per equipment specifications

6.2 Performance Measures

The manufacturer will be evaluated on the following measures:

- Adherence to the schedule – the ability to achieve milestones set forth by the Company.
- Delivery of materials – the materials are delivered to the Company in the timelines provided.
- Quality of materials – the materials adhere to the guidelines set forth in this specification.
- Adherence to safety – the ability to complete work safely with no lost time incidents.

6.3 Specification Deviations

Any deviations from this specification shall be identified and addressed as per the TEP-INT-MOC *Pipe Integrity Management of Change Procedure*. Deviations are to be reviewed and accepted by the Company's representative before acceptance of the deliverables, data or report.

6.4 Nonconformance Management

All nonconformances to the specification will be identified by the vendor, and reviewed and dispositioned by the Company.

APPENDIX

APPENDIX A APPROVED MATERIAL LIST

Table A-1: Approved Material List

Material Type	Manufacturer	Description	Model	Size (Metric)	Size (Imp)
Anodes	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2660	Length: 1524 mm Diameter: 66 mm Mass: 23 kg (nominal)	Length: 60 in Diameter: 2.6 in Mass: 50 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2684	Length: 2134 mm Diameter: 66 mm Mass: 31 kg (nominal)	Length: 84 in Diameter: 2.6 in Mass: 68 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	3884	Length: 2134 mm Diameter: 97 mm Mass: 31 kg (nominal)	Length: 84 in Diameter: 3.8 in Mass: 68 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2660Z	Length: 1524 mm Diameter: 69 mm Mass: 23 kg (nominal)	Length: 60 in Diameter: 2.7 in Mass: 50 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2684Z	Length: 2134 mm Diameter: 69 mm Mass: 32 kg (nominal)	Length: 84 in Diameter: 2.7 in Mass: 70 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	3884Z	Length: 2134 mm Diameter: 76 mm Mass: 41 kg (nominal)	Length: 84 in Diameter: 3.0 in Mass: 90 lb (nominal)
		Graphite Center Tap Anode	Varies depending on supplier	Length: 1016 mm Diameter: 102 mm Mass: 16 kg (nominal)	Length 40 inch. Diameter 4 inch Mass: 35 lb. (nominal)
		Graphite Center Tap Anode	Varies depending on supplier	Length: 1524 mm Diameter: 76 mm Mass: 12 kg (nominal)	Length 60 inch. Diameter 3 inch Mass: 27 lb. (nominal)

Table A-1: Approved Material List (Cont'd)

Material Type	Manufacturer	Description	Model	Size (Metric)	Size (Imp)
		Graphite Center Tap Anode	Varies depending on supplier	Length: 2032 mm Diameter: 102 mm Mass: 29 kg (nominal)	Length 80 inch. Diameter 4 inch 64 lb.
		Mixed Metal Oxide Anode	Varies depending on supplier	As specified on the purchase order.	As specified on the purchase order.

APPROVALS

Originator/Document Contact: Mark Whittington Corrosion Specialist Pipe Integrity, Corrosion Prevention	Mark Whittington Signature	4/8/14 Date
Reviewer: Tim Leitao, P. Eng. Senior Engineer Pipe Integrity, Corrosion Prevention	Tim Leitao Signature	April 8, 2014 Date
Reviewer: Brent McKinnon Program Management Canadian Pipeline Maintenance Projects	Signature	April 8, 2014 Date
Reviewer: David Gulen Program Management U.S. Pipeline Maintenance Projects	Signature	4/9/14 Date
Design Discipline Checker/ Responsible Engineer/Approver/ Engineer-in-Charge/Document Contact: Chad Khattar, P. Eng Senior Engineer Pipe Integrity, Corrosion Prevention	Signature Apr 14/2014 Date	APEGA Permit to Practice P7100
Management Endorsement: James Card, BSEE Manager Pipe Integrity, Corrosion Prevention	James Card Signature	4/14/14 Date

SUMMARY

This specification establishes the requirements for cathodic protection materials to install cathodic protection facilities for Company gas and hazardous liquid pipeline systems in Canada and the United States.

DOCUMENT HISTORY

Rev. No.		
06	**Description**	**Effective Date**
	Revised Section 9.8 and referenced Appendix A Table A-2 and Figures A-1, A-2, A-3 and A-4. This gives better direction in which insulators should be used below and above ground. In Section 20 added Pin Brazing as an acceptable application in the US only to install test leads. In Section 24.8 additional information was added about the equipment.	2014-Apr-08
	Rationale Statement	**Responsible Engineer**
	Annual Review of document.	Chad Khattar
	Impact Assessment Summary	**Team Owner**
	The additions to this document will not impact operations and will not require additional training.	Corrosion Prevention, Pipe Integrity
05	**Description**	**Effective Date**
	Editorial and format changes throughout the document.	2013-Jan-21
	Rationale Statement	**Responsible Engineer**
		Brad Woloschuk
	Impact Assessment Summary	**Team Owner**
	This specification establishes the requirements for cathodic protection materials for the installation of cathodic protection facilities for Company gas and hazardous liquid pipeline systems in Canada and the United States.	Pipe Integrity, Corrosion Prevention
04	**Description**	**Effective Date**
	Specification revised to apply in the United States. Code and references revised.	2009-Oct-15
	Rationale Statement	**Responsible Engineer**
	This Specification shall be used in all activities related to cathodic protection, including design, construction, operations and maintenance of Company facilities in Canada and in the United States.	Brad Woloschuk
	Impact Assessment Summary	**Team Owner**
		Engineering and Asset Reliability
03	**Description**	**Effective Date**
	Updated cable specs, anode specs, coke specs, vent piping specs, rectifier specs, test station reference drawings, junction & terminal box specs, and reference electrode specs. Updated anode lead attachment quality requirements Updated anode manufacturing approval.	2008-Aug-11
	Rationale Statement	**Responsible Engineer**
		Matt Cetiner
	Impact Assessment Summary	**Team Owner**
		Engineering

02	**Description**	**Effective Date**
	Coke breeze requirements updated and a materials summary list was added to the Appendix. Alberta drain lead cable colors (AWG #4 cable) were changed to black and white and the mainline uses red and white.	2005-Jul-13
	Rationale Statement	**Responsible Engineer**
		Garry Norton
	Impact Assessment Summary	**Team Owner**
		Pipe Engineering
01	**Description**	**Effective Date**
	Major revisions to the content.	2001-Dec-15
	Rationale Statement	**Responsible Engineer**
	This specification establishes the requirements for cathodic protection materials.	Wayne Corcoran Corey Goulet
	Impact Assessment Summary	**Team Owner**
	Drawing revisions and the addition of AC Mitigation Devices and general editing.	Engineering and Operation Services (E&OS)
00	**Description**	**Effective Date**
	New document.	1999-Jul-01
	Rationale Statement	**Responsible Engineer**
	This specification establishes the requirements for cathodic protection materials.	Burke Delanty Robert Basaraba
	Impact Assessment Summary	**Team Owner**
	This specification replaces Nova Gas Transmission Ltd. Cathodic Protection (CP) Materials Specification, Revision 1998-04-06. This specification replaces TransCanada PipeLines Rectifier Specification, Revision 1997-03-23.	Quality, Standards and Technology

BRIEF DESCRIPTION OF CHANGE

REGULATORY	
Section	**Description of Change**
	N/A
INDUSTRY STANDARDS	
Section	**Description of Change**
	N/A
GENERAL	
Section	**Description of Change**
	Editorial and format changes throughout.
	Revised Section 9.8 and referenced Appendix A Table A-2 and Figures A-1, A-2, A-3 and A-4. This gives better direction in which insulators should be used below and above ground. In Section 20 added Pin Brazing as an acceptable application in the US only to install test leads. In Section 24.8 additional information was added about the equipment.

DEVIATION FROM THIS SPECIFICATION

TransCanada Engineering Standards and Specifications must be followed by internal and external users to ensure a safe, reliable and technically correct design.

Deviations to this standard may be acceptable if a technical assessment approved by TransCanada Engineering Specification Owner shows that the deviation meets the intent of this specification, does not compromise safety and also complies with applicable industry standards, regulatory requirements and is consistent with good engineering judgment.

Any deviation must follow the appropriate TransCanada management of change variance procedure.

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DEFINITIONS

Term	Definition
AC	alternating current
ACSR	aluminum conductor steel-reinforced cable
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
CEC	Canadian Electrical Code
Company	TransCanada Corporation
CSA	Canadian Standards Association
DC	direct current
ECTFE	ethylene chlorotrifluoroethylene
HMW-MDPE	high molecular weight high density polyethylene
HMWPE	high molecular weight polyethylene
ID	inside diameter
IEC	International Electrotechnical Commission
LED	light emitting diode
NACE	NACE International
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
OD	outside diameter
PCR	polarization cell replacement
RMU	remote monitoring unit
TEG	thermoelectric generator
UV	ultra violet
XLPE	cross-linked polyethylene

Tools and Applications	
Incident and Issue Tracking (IIT)	An electronic database tool used to report incidents and issues involving employees, contractors and third parties.
FileNet-EDMS	The Company's web-based electronic document management system.

1 PURPOSE

This specification establishes the requirements for cathodic protection materials to install cathodic protection facilities for the Company's buried pipeline systems in Canada and the United States.

This specification shall be used:

- By Company employees and all prime and subcontractors employed by the Company
- In all activities related to cathodic protection, including design, construction, operations and maintenance

Materials supplied shall meet all requirements of this specification and any additional requirements on the applicable request for quotation, purchase order and applicable Company standard drawings.

Before a material is added to the approved material list, it shall be reviewed and approved by the Company's cathodic protection engineering personnel.

2 SCOPE

This specification applies to materials for cathodic protection for the Company's gas and hazardous liquid pipeline systems in Canada and the United States.

3 REFERENCES

3.1 Regulations Codes and Standards

The jurisdictional regulations and legal requirements that apply to this specification are:

- 49 Code of Federal Regulations (CFR):
  - 192, Subpart I
  - 195, Subpart H
- Canadian Standards Association (CSA):
  - Z662-11 Oil and Gas Pipeline Systems, Section 9
  - C22.1 Canadian Electrical Code (CEC), Part I, Safety Standard for Electrical Installations (Section 80)
  - C22.2 No. 107.1, General Use of Power Supplies
  - C22.2 No. 131, Type TECK 90 Cable
  - C22.2 No. 75, Thermoplastic-Insulated Wires and Cables (Tri-National standard, with UL 83 and NMX-J-010-ANCE, 2008)
  - Special Publication SPE-1000-94, Model Code for the Field Evaluation of Electrical Equipment
  - Ontario Hydro Electrical Safety Code, Section 7
  - Ontario Hydro Specifications 31, 32, 33, or Table 100
- National Fire Protection Association (NFPA) 70 National Electrical Code (NEC)

3.2 Industry Publications and References

The industry publications and references that apply to this specification are:

- NACE International:
  - SP0169-2007, Control of External Corrosion on Underground or Submerged Metallic Piping Systems
  - SP0572-2007, Design, Installation, Operations, and Maintenance of Impressed Current Deep Anode Beds
- American Society for Testing and Materials (ASTM) International:
  - G97, Standard Test Method for the Laboratory Evaluation of Magnesium Sacrificial Anode Test Specimens for Underground Applications
  - B265, Standard Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate
  - B418, Standard Specification for Cast and Wrought Galvanic Zinc Anodes
  - B843, Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
  - A518, Standard Specification for Corrosion-Resistant High-Silicon Iron Castings
  - D1248, Standard Specification for Polyethylene Plastics Molding and Extrusion Materials For Wire and Cable
  - D2000, Standard Classification System for Rubber Products in Automotive Applications
  - B3, Standard Specification for Soft or Annealed Copper Wire
  - B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
  - D293, Standard Test Method for the Sieve Analysis of Coke
  - D709, Standard Specification for Laminated Thermosetting Materials
  - D3172, Standard Practice for Proximate Analysis of Coal and Coke
  - D3173, Standard Test Method for Moisture in the Analysis Sample of Coal and Coke
  - D3174, Standard Test Method for Ash in the Analysis Sample of Coal and Coke from Coal
  - D3178, Standard Test Method for Ultimate Analysis for Hydrogen Content
  - D5142, Standard Test Methods for Proximate Analysis of the Analysis Sample of Coal and Coke by Instrumental Procedures
  - D4239, Standard Test Methods for Sulphur in the Analysis Sample of Coal and Coke Using High Temperature Tube Furnace Combustion Methods
  - D4749, Standard Test Method for Performing the Sieve Analysis of Coal and Designating Coal Size
- American Society of Mechanical Engineers (ASME) B16.21, *Nonmetallic Flat Gaskets for Pipe Flanges*

- International Electrotechnical Commission (IEC):
  - 60060-1, High-voltage test techniques, Part 1: General definitions and test requirements
  - 60060-2, High voltage test techniques, Part 2: Measuring systems
  - 60228, Conductors of Insulated Cables
- National Electrical Manufacturers Association (NEMA):
  - WC70/ICEA S-96-658, Thermoplastic Insulated Wire & Cable for Transmission & Distribution
  - Standard Publication Number MR 20-1958 (reaffirmed by NEMA 1971) – *Semiconductors, Rectifiers, Cathodic Protection Units*
  - Standard Publication No. MR 250-1979 (including Rev No. 1 December 1980), *Enclosures for Electrical Equipment (1000 Volts Maximum)*

3.3 Internal References

The Company procedures, guidelines, reports and documents that apply to this specification are:

- TED-CP-DD *Cathodic Protection Design Directive (CDN-US)* (EDMS No. 003746511)
- TEP-INT-MOC *Pipe Integrity Management of Change Procedure* (EDMS No. 006425143)
- *Operations and Maintenance (O&M) Manual – U.S. Natural Gas Pipelines* (EDMS No. 005404490)
- *TransCanada O&M Manual – U.S. Hazardous Liquids Pipelines* (EDMS No. 005713585)
- *Operator Qualification Program (US)* (EDMS No. 004504739)
- *Operator Qualification Program for Construction of Pipelines covered by 49 CFR §192.620 & under Special Permit of 49 CFR §195* (EDMS No. 005713585)

4 ROLES, RESPONSIBILITIES AND QUALIFICATIONS

4.1 Vendor Responsibilities and Qualifications

4.1.1 Requirements for All Materials

Following are material requirements:

- The manufacturer shall be on the Company's cathodic protection Approved Materials List (see Appendix A) for the production of cathodic protection materials.
- The manufacturer shall supply to the Company, at the time of quotation, any exceptions or alternatives to this specification.

4.1.2 Preproduction Provisions

For isolation sets, the manufacturer shall submit to the Company the following:

- For each sleeve size, the inside diameter (ID), outside diameter (OD), thickness and length (all in millimetres or inches), material type and the dielectric strength (volts per 1 mm or in.).

- For each washer type and size, the ID, OD and thickness (all in millimetres or inches), material type, and if applicable, dielectric strength (volts per 1 mm or 1 in.).

For rectifiers, the manufacturer shall submit to the Company:

- A certification that the rectifier meets the requirements of this specification
- A nationally recognized testing laboratories (NRTL) approval certification
- A circuit diagram and dimensions of the enclosure

For:

- Thermoelectric generators (TEG), the manufacturer shall certify that the TEG(s) meet the requirements of this specification, and provide a diagram showing the components of the TEG(s) and dimensions of the enclosure(s).
- Calcined coke, the manufacturer shall submit a datasheet detailing the chemistry and other requirements in Section 7.
- Cables, the manufacturer shall certify that the cable meets the requirements of the Canadian Electric Code (CEC) or the NEC (as applicable), ASTM D 1248 or NACE Standard SP0572 and this specification.
- Each monolithic isolator, the manufacturer shall submit to the Company the fabrication drawing and the production schedule.
- Remote monitoring equipment and rectifiers, the manufacturer shall supply laminated electrical schematic drawings with each rectifier, and copies shall be submitted to the Company.

4.2 Company Responsibilities

The Company representative shall obtain all QA/QC documents for materials to be installed, in accordance with the project description. At the request of a Company Representative, cathodic protection material may be retained by the Company for evaluation to ensure the material conforms to this specification.

The Company shall have the right to review the manufacturer's work at any time.

5 ANODES

5.1 High-Potential Magnesium Anodes

5.1.1 Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass and dimensions are as follows:

- The anode shall conform to ASTM B843, Grade M1C.
- The anode shall have a minimum efficiency of 43%, when tested in accordance with ASTM G97.
- The mass of the anode, anode dimensions and package dimensions shall be as specified on the purchase order.
- A galvanized steel core shall be cast at least 75% of the full anode length.

5.1.2 Lead Wire

See Section 6, magnesium anodes or zinc anodes.

5.1.3 Backfill

See Section 7

5.1.4 Markings

The anode type, mass (kg/lb) and Company specification and revision date shall be legibly marked on each anode package with a weather-resistant marker or a label (e.g., High potential magnesium, 15 lb, TES-CP-MS [Cdn-US], 2012/10/01).

5.1.5 Shipping

Shipping specifications are as follows:

- The backfill package shall consist of a cotton bag or wettable (e.g., no wax or plastic coated) cardboard tube with the dimensions as specified on the purchase order.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to ultra violet (UV) rays, or as directed by the supplier.

5.2 Zinc Ribbon

5.2.1 Chemical Composition, Mass and Dimensions

Chemical composition, mass and dimension specifications are as follows:

- The chemical composition of zinc ribbon shall conform to ASTM B418, Type II. The anode dimensions shall be as specified on the purchase order or Company standard drawings.
- The anode shall be manufactured by extrusion with a continuous centered 1/8 in. galvanized steel core.

5.2.2 Lead Wire

Not applicable.

5.2.3 Backfill

Not Applicable.

5.2.4 Markings

The following shall be legibly marked with a weather-resistant marker on a tag attached to the reel (or another device that the anode is wrapped around):

- manufacturer
- anode model
- ribbon type
- cross section (X millimetres [inches] x Y millimetres [inches])
- length (metres or feet)
- Company specification and revision date

For example, "manufacturer", aaa, zinc ribbon, 12 mm x 15 mm, 500 m, TES-CP-MS (Cdn-US), 2012/10/01.

5.2.5 Shipping

Shipping specifications are as follows:

- The ribbon shall be packaged in a manner to allow for ease of shipping.
- The zinc ribbon shall be prepared for shipment and storage in such a manner that it will not be exposed to weather or water, as directed by the supplier.

5.3 Zinc Grounding Cells

5.3.1 Chemical Composition, Mass and Dimensions

The chemical composition for the zinc shall conform to ASTM B418, Type II. The anode dimensions shall be as specified on the purchase order or Company standard drawings.

5.3.2 Lead Wire

See Section 6, magnesium anodes or zinc anodes.

5.3.3 Backfill

See Section 7

5.3.4 Markings

The anode type, mass (kilograms or pounds) and the Company specification and revision date shall be legibly marked on each anode package with a weather-resistant marker or a label (e.g., Zinc grounding cell, 7.7 kg, TES-CP-MS [Cdn-US], 2012/10/01).

5.4 Silicon-Chromium Cast Iron Anodes

5.4.1 Chemical Composition, Mass and Dimensions

The following clauses shall apply to both tubular and stick anode castings:

- The anode shall be chill cast or equal, from an alloy conforming to ASTM A518 GR3.
- Each anode shall be supplied free from casting defects, porosity, voids and fissures. The anode surface shall be free from adhering foundry sand or mould release agents.

- The anode mass and anode dimensions shall be as specified on the purchase order, or Company standard drawings.
- All anode manufacturers shall be approved by the Company.

5.4.2 Lead Wire

See Section 6

5.4.3 Markings

The following shall be legibly marked with a weather-resistant marker on a tag attached to the anode:

- manufacturer
- anode model
- anode type
- anode mass (kilograms or pounds)
- anode OD (millimetres or inches)
- length (millimetres or inches)
- Company specification
- revision date

For example, "manufacturer", aaa, stick, 20 kg, 50 mm, 1520 mm, TES-CP-MS (Cdn-US), 2012/10/01.

5.4.4 Shipping

Shipping specifications are as follows:

- Anodes shall be packaged in a manner to avoid breaking during shipment.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water, as directed by the supplier.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.5 Continuous Polymer Anodes

5.5.1 Chemical Composition, Mass and Dimensions

Specifications for chemical compositions, mass and dimensions are as follows:

- Continuous polymer anodes shall be constructed as stranded American Wire Gauge (AWG) 6 annealed copper conductors with a conductive polymer jacket (rather than an insulating polymer jacket).
- The conductive polymer jacket shall provide a moisture-proof barrier to protect the copper cable.
- The conductive polymer jacket shall be capable of continuously discharging a current of 50 mA per linear metre (15 mA per linear foot) of anode material for a minimum of twenty years.

5.5.2 Lead Wire

See Section 6

5.5.3 Backfill

See Section 7

5.5.4 Markings

The following shall be legibly marked with a weather-resistant marker on a tag attached to the anode:

- manufacturer
- anode model
- polymer type
- length (metres or feet)
- Company specification
- revision date

For example, "manufacturer", aaa, carbon impregnated polyethylene, 500 m, TES-CP-MS (Cdn-US), 2012/10/01).

5.5.5 Shipping

Shipping specifications are as follows:

- As specified on the purchase order or Company standard drawings, continuous polymer anodes may be supplied bare (by itself) or prepackaged in a 38 mm (1½ in.) diameter flexible mesh tube.
- Prepackaged conductive polymer anodes shall contain a high-grade coke backfill conforming to Section 7. The conductive polymer anode shall be centered within the flexible mesh tube.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water, as directed by the supplier.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.6 Canister Anodes

5.6.1 Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass and dimensions are as follows:

- Only tubular anodes shall be placed in canisters. Anodes shall meet the requirements of Section 5.6.2 before assembly.
- The canisters shall be manufactured as follows:
  - spiral corrugated perforated galvanized steel – 28 gauge minimum
  - diameter – 225 mm to 235 mm (8 in.) minimum
  - length – anode length + 600 mm (2 ft)
  - plywood end caps – 16 mm (¾ in.) minimum thickness

5.6.2 Assembly

High silicon-chromium anode assemblies shall be canistered as follows:

- With the bottom end cap in place, the anode shall be centered in the can and filled with coke, such that the anode has 200 mm (8 in.) of coke beyond each anode end.
- Calcined petroleum coke, as per Section 7 shall be mechanically compacted around the anode.
- An inner plywood cap shall be secured to the can immediately above the compacted calcined petroleum coke.
- A steel bolted eyelet shall be attached to the top inner plywood cap, and the lead wire shall exit through a close fitting hole to the side of centre.
- The wire shall be coiled and placed on the inner cap.
- A top end cap, with access to the coiled wire, shall be attached to protect the coiled wire during shipping.

Refer to Company standard drawings.

5.6.3 Shipping

Shipping specifications are as follows:

- All canned anodes shall be securely attached to a pallet in such a manner to avoid damage to the anodes or canisters.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water, as directed by the supplier.
- All anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.7 Graphite Anodes

5.7.1 Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass and dimensions are as follows:

- The chemical composition for the graphite shall be GR060CP grade or equal.
- The graphite shall be treated with wax or resin, as specified on the purchase order.
- Centre connections shall be tested to verify that the connection falls below 0.004 ohms (4 milliohms).

5.7.2 Lead wire

See Section 6

5.7.3 Backfill

See Section 7

5.7.4 Shipping

Shipping specifications are as follows:

- Anodes shall be packaged in a manner to avoid breaking during shipment.

- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water.
- The anode lead wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

5.8 Mixed Metal Oxide Anodes

5.8.1 Chemical Composition, Mass and Dimensions

Specifications for chemical composition, mass and dimensions are as follows:

- The chemical composition of titanium shall conform to ASTM B265.
- The anode rating per foot and length is as specified on the purchase order.

5.8.2 Lead wire

See Section 6

5.8.3 Backfill

See Section 7

5.8.3 Shipping

Shipping specifications are as follows:

- Anodes shall be packaged in a manner to avoid damage during shipment.
- The packaged anodes shall be prepared for shipment and storage in such a manner that the anodes will not be exposed to weather or water.
- The anode wires shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

6 CABLE

6.1 General

General specifications for cable are as follows:

- All cable shall be rated for use from -40°C to 60°C, or -40˚F to 140˚F.
- Cables shall have an underground rating.
- All cables shall conform to ASTM B3 and ASTM B8 or IEC 60228.
- All cables shall be rated to handle 600 V direct current.
- Unless specified, the cable size, cable length and cable colour shall be as indicated on the purchase order or Company standard drawings.
- The outer insulation layer shall be marked to include the manufacturer, conductor size and number of strands (e.g., "manufacturer," AWG 4, 7/S).

6.2 Anode Lead Wire

6.2.1 Magnesium Anodes or Zinc Anodes

Specifications for magnesium anodes or zinc anodes are as follows:

- The anode lead wire shall be a continuous seven stranded, AWG 10 or larger (unless specified on the purchase order) annealed copper conductor, minimum 3 m (10 ft) long. The insulation shall be blue for magnesium anodes and white for zinc, unless specified on the purchase order, to be consistent with site-specific installations. The insulation shall be RWU90 cross-linked polyethylene (XLPE), or direct-burial high molecular weight polyethylene (HMWPE).

- Lead wires shall be attached to the galvanized steel core by silver solder, and the connection shall be made moisture-proof by encapsulating the connection with an electrical sealing compound. The lead wire connection shall withstand a steady load pull of 200 kg (440 lb) without separation from the anode.
- For zinc grounding cells, the lead wire shall be a continuous seven stranded, AWG 2, or larger, annealed copper conductor, minimum 3 m (10 ft) long. The insulation shall be white for zinc anodes. The insulation shall be RWU90 XLPE, or direct burial HMWPE. The wire shall be compression connected to the anode core and sealed with an electrical sealing compound.
- If magnesium anodes are to be used with solar panels, the cables shall meet the requirements of an impressed current system.

6.2.2 Tubular Anodes

Specifications for tubular anodes are as follows:

For deep-well anode leads, see Deep Anode Lead Cable below.

- Unless otherwise specified, anode leads shall be AWG 8.
- The anode lead wire shall be a continuous conductor of AWG 8 with a seven-stranded copper conductor. The insulation shall be black, and shall consist of at least 2.78 mm (0.1 in.) of high molecular weight, medium density polyethylene that conforms to ASTM D 1248, Type II, Class C, Category 4, Grade J4E9.
- The use of lead (Pb) anchors for cable connections is not permissible.
- Attachment of the lead wire to the anode shall be made by a permanent compression connection. The lead wire connection shall be centered inside the anode.
- The anode lead wire shall be visually inspected before attaching the anchoring assembly, to ensure that none of the copper strands have been scored or scratched. Before applying the compression crimp connector, the copper strands of the lead wire shall be manually twisted into a compact spiral to facilitate even distribution of stress to each of the strands.
- The lead wire MDPE or HMWPE jacket surface shall be roughened for 50 mm (2 in.) anode end to improve adhesion to the sealant.
- The lead-wire centre connection to the anode shall be sealed using ArmorThane STS-200 Side A and Side B cured polyurethane, or approved equivalent. The sealant thicknesses shall be a minimum of 150 mm (6 in.) both above and below the centre connection. The depths (millimetre or inches) of top and bottom epoxy seals shall be measured by probing and recorded directly on the outside of all anodes with a permanent marker. In addition, the date and distributor name shall be marked with a permanent marker on the anode.
- The seller to the Company shall perform non-destructive random checks of sealant levels, as quality assurance that sealant levels marked on the outside of the anodes are correct. Records of quality assurance checks completed shall be sent to the Company before shipping. If any

nonconformances are indicated, all other anodes having the same assembly date and manufacturer shall be inspected and repaired as necessary to meet this specification.

- The lead wire connection to the anchoring assembly shall be destructively tested before and at the end of each production day, to ensure compression equipment is operating satisfactorily. In addition, each anode shall be manually (i.e., by hand) pull tested by the technician after the mechanical connection to the anode is completed. Pull tests shall not be performed after sealant application.
- All anode leads shall be tested to ensure electrical continuity to the anode after a sealant has cured and before shipping.
- Anode leads shall be attached in accordance with the anode manufacturer's recommended mechanical procedures. The anode manufacturer shall provide a lead-wire installation procedure to the anode supplier and Company. In case of conflict between this specification and manufacturer's recommended procedures, this specification shall apply.
- Attachment of the anode lead wire shall only be performed by previously approved distributors.

6.3 Other Cable

6.3.1 Negative Cable

Cables shall have stranded annealed copper wires. Insulation shall conform to NEMA WC70/ICEA S-96-658, have a minimum thickness of 2.78 mm (0.1 in.) and shall be high molecular weight, medium density polyethylene that conforms to either:

- ASTM D 1248, Type II, Class D, Category 4, Grade J4E9,
- ASTM D 1248, Type I, Class C, Category 5, Grade E5 and J1, or
- ASTM D 1248, Type I, Class A, Category 5, Grade E4 and E5

Minimum thickness of the HMWPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and a minimum of 18 strands for cable sizes larger than AWG 2.

6.3.2 Positive Cable

Cables shall have stranded annealed copper wires. Insulation shall conform to NEMA WC70/ICEA S-96-658, have a minimum thickness of 2.78 mm (0.1 in.) and shall be high molecular weight, medium density polyethylene that conforms to either:

- ASTM D 1248, Type II, Class C, Category 4, Grade J4E9,
- ASTM D 1248, Type I, Class C, Category 5, Grade E5 and J1, or
- ASTM D 1248, Type I, Class A, Category 5, Grade E4 and E5

The minimum thickness of the HMWPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and a minimum of 18 strands for cable sizes larger than AWG 2.

Cables shall have stranded annealed copper wires. Insulation shall conform to NEMA WC70/ICEA S-96-658, and shall be high molecular weight, medium density polyethylene that conforms to:

- ASTM D 1248 Type II, Class D, Category 4, Grade D6
- ASTM D 1248, Type I, Class C, Category 5, Grade E5
- J1 or ASTM D 1248, Type I, Class A, Category 5, Grade E4 and E5

The cable shall be tested for cold bend at -30°C (-22°F) and impact at -40°C (-40°F). Minimum thickness of the HMWPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and a minimum of 18 strands for cable sizes larger than AWG 2. The minimum thickness of the HMWPE shall be 4 mm (0.16 in.).

Note: Cable colour should be consistent with specific installation practices.

Alternatively, an additional 1.52 mm (0.06 mm) thick red PVC outer jacket shall be extruded over the 2.78 mm (0.1 in.) HMWPE black cable.

6.3.3 Armored Cable

Single conductor armored cable shall have stranded annealed copper wire. Insulation shall conform to NEMA WC70/ICEA S-96-658, have a minimum thickness of 2.78 mm (0.1 in.) and shall be high molecular weight, medium density polyethylene (HMW-MDPE) that conforms to ASTM D 1248, Type II, Class C, Category 4, Grade J4E9. Minimum thickness of the HMW-MDPE at any point shall be not less than 90% of the specified average thickness. Cable shall be intended for cathodic protection applications. The cables shall have seven strands for sizes up to, and including, AWG 2 and 19 strands for cable sizes larger than AWG 2. The middle layer shall consist of aluminum armour.

Multi-conductor armored cable shall be Teck 90, conforming to CSA C22.2 No. 131, or an ASTM equivalent. The middle layer shall consist of aluminum armor.

6.3.4 Single Jacket Cable – Test Leads and Sacrificial Anodes

Single-jacket cable shall be stranded copper conductor in sizes not larger than AWG 6 or less. Insulation shall be RWU-90 XLPE (-40°C/-40°F), with a thickness of 1.83 mm (5/64 in.) and conform to CSA C22.2 No. 38, or an ASTM equivalent.

6.3.5 Deep Anode Lead Cable

To resist chemical attack, cable for deep anode bed applications shall be ethylene chlorotrifluoroethylene (ECTFE) fluoropolymer (HALAR or equivalent) jacketed.

Dual-extrusion HALAR cable shall have stranded annealed copper wires. Insulation shall be a homogenous wall of natural ECTFE fluoropolymer (HALAR or equivalent) extruded over the conductor. Insulation shall conform to NEMA WC70/ICEA S-96-658 and the outer insulation shall be high molecular weight polyethylene conforming to ASTM D 1248, Type 1, Class C, Category 5, Grades E5 and J1. Average thickness of the HALAR insulation shall be 0.5 mm (0.02 in.). Minimum thickness at any point shall be not less than 90% of the specified average thickness. Average outer jacket insulation thickness shall be 1.6 mm (0.06 in.). The minimum thickness shall be not less than 80% of the specified average thickness. The completed cable shall be tested in accordance with the requirements of NEMA WC70/ICEA S-96-658.

6.4 Summary

Table 6-1 provides a summary of the cable specifications.

Table 6-1: Summary Cable Specifications

Description	Insulation Description	Insulation Thickness (min mm)	Insulation Thickness (min inch)	Colours Specified
Armoured cable, AWG 2, 4	Inner: HMW-MDPE	2.78	7/64	N/A
	Middle: Aluminum armour	Standard	Standard	N/A
	Outer: Coloured PVC	1.52	1/16	Per site-specific construction drawings
AWG 2, 4 mainline positive cable (Option 1)	Inner: HMW-MDPE	2.78	7/64	Black
	Outer: Coloured PVC	1.52	1/16	Red
AWG 2, 4 mainline positive cable (Option 2)	HMW-MDPE	4.00	5/32	Red
AWG 2, 4 Alberta positive cable	HMW-MDPE	2.78	7/64	Black
AWG 4 negative cable	HMW-MDPE	2.78	7/64	White
Single jacket cable AWG 6	RWU-90 XLPE (-40°C/-40°F)	1.83	5/64	Per site-specific construction drawings
Single jacket cable AWG 8	RWU-90 XLPE (-40°C/-40°F)	1.83	5/64	Per site-specific construction drawings
Single jacket cable AWG 10, 12	RWU-90 XLPE (-40°C/-40°F)	1.83	5/64	Per site-specific construction drawings
Dual extrusion (HALAR or approved equivalent)	Inner: ECTFE fluoropolymer	0.5	2/100	Per site-specific construction drawings
	Outer: ASTM D 1248 (colored)	1.6	1/16	Per site-specific construction drawings
No. 2 ACSR	N/A	N/A	N/A	Per site-specific construction drawings

For shipping, all cables (i.e., anode lead wires, cable spools and test station wires) shall be wrapped in weather-tight plastic opaque to UV rays, or as directed by the supplier.

6.5 Splice Kits

Splice kit specifications are as follows:

- Epoxy splice kits shall contain a plastic mold, which completely surrounds the crimped cable connection and seals the cables such that the epoxy does not leak out during the cure time. Kits shall contain tape to seal the points at which the cables enter the plastic mold. Epoxy mixture shall cure in 30 minutes at temperatures of 15°C (60°F) and above. Kits shall also be rated up to 1000 V.
- Heat-shrink splice kits shall contain, as a minimum, an adhesive coated polyethylene sleeve, mastic filler and black cloth tape, or a Company approved equivalent. The sleeve shall extend 50 mm (2 in.) beyond each end of the connection. Refer to Company standard drawings.
- For splicing and sealing of continuous polymer anodes, only end caps, splice kits and tees that are approved by the conductive polymer anode manufacturer shall be used.
- Rubberized 3M slicing tape and the 3M Scotchkote Electrical Coating may be used on above ground splices in junction boxes.

6.6 Direct Current Pole line and Cables

Direct current (DC) pole line and cable specifications are as follows:

- The poles shall be minimum 12.2 m (40 ft) long, Class 5, with Penta #8 retention, or CCA-peg treatment.
- The conductor shall be No. 2 ACSR cable, unless specified otherwise.
- Rock anchors for the poles shall be Tri-Anchor Line Pole Rock Anchor type 8-18-28.
- All pole line hardware shall be galvanized according to Ontario Hydro Electrical Safety Code, Section 75, or equivalent.
- Guy wires shall be stranded steel. The wires shall be galvanized and have a diameter of 9 mm (3/8 in.) minimum. Guy guards are required at all installed locations. Guy guards are to be made of plastic, and provide visual identification for public safety. The guards shall be secured to the guy wire using the manufacturer's supplied hardware.
- Insulators shall be selected in accordance with Ontario Hydro Specifications 31, 32, 33, or Table 100 or equivalent.

7 COKE AND OTHER BACKFILL

7.1 General

All coke supplied shall be calcined, and all coke tests shall be conducted as per the referenced test methods.

7.2 Chemistry

The composition and tests methods are based on dry weight, and are outlined in Table 7-1.

Table 7-1: Test Methods and Coke Composition

Category	Test Method	Shallow Anodes	Deep Anodes	Continuous Polymer Anodes
Carbon (fixed)	ASTM D3172 or D5142	98.7% minimum	99.2% minimum	99.2% minimum
Ash	ASTM D3174 or D5142	0.60% maximum	0.60% maximum	0.60% maximum
Sulfur	ASTM D4239	6% maximum	6% maximum	6% maximum
Moisture	ASTM D3173 or D5142	0.20% maximum	0.20% maximum	0.20% maximum
Hydrogen	ASTM D5373 (ultimate analysis for hydrogen content)	0.10% maximum	0.10% maximum	0.10% maximum

7.3 Other Requirements

Coke for deep anodes and continuous polymer anodes shall be dust-free. No de-dusting oils shall be used in the manufacture of the calcined coke.

Coke shall meet or exceed the requirements outlined in Table 7-2.

Table 7-2: Other Requirements for Coke

Category	Test Method	Shallow Anodes	Deep Anodes	Continuous Polymer Anodes
Bulk density	Modified ASTM D4292	≥975 kg/m^3	≥1,100 kg/m^3	≥1,100 kg/m^3
Resistivity	Carbon industry test C12A @ 150 psi (dry basis)	<0.2 Ωcm	<0.2 Ωcm	<0.2 Ωcm
Particle size	ASTM D293 or ASTM D4749	#4 Mesh - 95% #200 Mesh - 5%	#12 mesh -100% #200 mesh - 5%	#12 mesh - 100% #200 mesh - 5%

Note: Particle size is listed as a percentage of coke passing through the screen.

For deep and continuous anode installations, Loresco SC-3 Coke Breeze, TC-Alcoke/Z0637 Coke Breeze and Asbury 251-P Coke Breeze, or a Company-approved equivalent are acceptable.

For shallow anode installations, Loresco DW-1 Coke Breeze, TC-Alcoke/Z0637, or a Company approved equivalent is acceptable.

The coke breeze supplier shall provide the Company with a Certificate of Analysis for each batch or lot (as specified by manufacturer) of coke breeze indicating that the coke breeze meets Company specifications.

7.4 Conductive Carbon Grout

Conductive carbon grout specifications follow:

- In areas where the current discharge zone could lead to the interchange flow between water-bearing formations, conductive carbon grout shall be used in the annular to form a conductive seal.
- The mixture of grout and round-grain calcined petroleum coke particles shall have additional additives to minimize the apparent viscosity of the slurry.
- The coke particles shall meet the minimum coke requirements listed above.

7.5 Other Backfill

The anode shall be centered in the backfill.

Backfill surrounding magnesium anodes shall have the following composition and properties:

- gypsum – 75% to 80%
- bentonite – 15% to 20%
- sodium sulphate – 0% to 5%

Backfill surrounding the zinc grounding cells shall have the following composition and properties:

- gypsum – 80% to 85%
- bentonite – 15% to 20%
- sodium sulphate – 0% to 5%

7.6 Shipping

All backfill shall be wrapped in weather and water-tight UV-resistant plastic. All backfill packaging shall be clearly labeled with material designations, as specified in Sections 7.10 and 7.11.

8 DEEP ANODE VENTING

Deep-anode venting specifications are as follows:

- Venting of gases shall be allowed for a full 360 degrees of the vent pipe without a loss of pipe strength.
- Vertical slits are preferred, and shall be 3.8 cm (1½ in.) in length, or greater, and shall be 0.015 cm (1/64 in.) in width.
- The diameter of piping shall be 25.4 mm (1 in.) inside diameter and 32.3 mm (1¼ in.) outside diameter.
- Material shall be non-conducting and resistant to chlorine attack, if chlorine is a possibility.
- Lengths of pipe joints shall be in either 3 m (10 ft) or 6 m (20 ft) lengths.
- If plowing is used, vent piping from a deep well to a vent termination point shall be 1 in. non-perforated coiled HDPE pipe. The minimum outside diameter of HDPE pipe shall be 33.4 mm (1.3 in.) and the minimum wall thickness shall be 3.02 mm (0.1 in.).

9 ISOLATION SETS

9.1 Flange Isolating Kit

Flange isolating kit specifications are as follows:

- These devices shall be pressure rated for the intended use, as shown on the Company standard drawing.
- Washers shall be zinc-plated steel.
- G10 retainer or gasket face shall be a Type F glass reinforced epoxy.
- Viton or Teflon shall be used as the sealing element.
- G10 insulation sleeves shall be used with insulation sets.
- Double washer set is required for aboveground applications, which will include two steel washers and two G10 isolating washers for each stud or bolt.
- G10 one piece sleeve and washer sets, or full length sleeves and single washer set configuration is required for below-ground installations to allow the cathodic protection current to protect the nuts and bolts of the buried flange.
- See Appendix A, Table A-1, Table A-2 for the approved material list. Figures A-1, A-2, A-3 and A-4 for examples of sleeve and washer configurations

9.2 Monolithic Isolators

Monolithic isolator specifications are as follows:

- Metal components (excluding pipe-end pups) shall be forged steel.
- Pipe-end pups shall conform to the requirements for each installation, as specified on the purchase order or Company standard drawings.
- "Stiff" electrical isolating components shall consist of glass-reinforced epoxy composite conforming to ASTM D709, Type IV, Group G.10 requirements (G.11 is an acceptable alternative).

- Elastomeric sealing elements shall consist of nitrile butadiene rubber, conforming to ASTM D2000.
- Insulating filler materials shall consist of epoxy resin without solvents.
- Adhesive sealant elastomeric materials shall be silicon.
- Each device shall be tested as follows:
  - Electrical test – each monolithic isolator shall be tested according to the requirements of the IEC 60-1 and 60-2
  - DC resistance test – each isolator shall maintain a resistance of at least 5 MΩ for one minute at an applied stress of 1000 VDC
  - Alternating current (AC) resistance test – each isolator shall maintain a resistance of at least 1 MΩ for one minute at an applied stress of 5000 VAC (50-60 Hz)

9.3 Isolating Unions

Isolating union specifications are as follows:

- Metal components shall be forged steel.
- Isolating union shall be insulated against galvanic corrosion.
- The tailpiece shall be coated with a tough-baked industrial thermo-setting epoxy, bonded directly to the metal.
- A Teflon shoulder gasket shall be provided for extra-wear resistance.
- Insulating properties – exceeds 500 V dielectric resistance.

10 RECTIFIERS

10.1 General Information

General specifications for rectifiers are as follows:

- Rectifiers shall be designed to operate continuously at temperatures between -40°C and 50°C (-40°F and 122°F).
- The DC voltage output shall be fully isolated from the line voltage.
- Rectifiers shall have a primary and secondary arrestor designed to protect against electrical transients caused by lightning, induction and switching surges.
- Output ratings shall be as specified on the purchase order and Company standard drawings.
- The AC input of all rectifiers shall be single phase, 60 Hz, AC 230 V, or as specified on the purchase order and Company standard drawings.
- The AC input lugs are to be sized to accommodate an AWG 2 and to provide a “dead front” for connection to the AC line.
- All rectifiers are to be equipped with an AC 115V, 15A, 3-pin ground fault interrupt- (GFI) service receptacle. This receptacle is to be connected between the hot and the neutral through a fully magnetic circuit breaker from the line side of the rectifier’s main circuit breaker. This receptacle is to be mounted on the front of the panel for easy access.
- Rectifying elements shall be silicon solid state and de-rated to 50% of the manufacturer’s current rating at 100°C (212°F). Silicon diodes shall be constructed into a single-phase full

wave bridge configuration. Heat sinks shall be sized to keep diode junction and core temperatures from exceeding 100°C (212°F) in 45°C (113°F) ambient conditions. Diodes shall have a minimum peak inverse voltage (PIV) of 800 V. Where applicable, clear chromate finish aluminum heat sinks (per MIL-C-5541) are acceptable. NOTE: ROHS (restrictions of hazardous substances) disallows anodizing due to use of sulphuric and chromic acids.

- All cables, including jacket materials, shall be suitable for handling, and shall be rated to operate continuously over a temperature range -40°C to +105°C (-40°F to 220°F) ambient air temperature. Alternatively, all cables shall have the insulated jacket coatings de-rated according to applicable electrical codes or standards (Canadian and US) to satisfy the ambient air-temperature operating range.

10.2 Enclosure

Enclosure specifications are as follows:

- Enclosures for air-cooled cathodic protection rectifiers shall be constructed to CSA Enclosure 3R Classification, as required by CSA C22.2, No. 107.1 or NEMA MR 20 and NEMA MR 250. The rectifier case shall be NEMA 3R, and completely weatherproof for outdoor use.
- Minimum sheet metal thickness shall be 12 gauge, wiped coat mill-galvanized steel, as per ASTM 123 and, when practical, the cabinet shall be equipped with a slide-out chassis. Enclosures shall be vented for natural air convection and screened against insects. Screens shall be reinforced to provide structural integrity to the rectifier cabinet. Screens over openings shall meet the requirements set forth by CSA C22. No. 107.1. Hinges and enclosure assembly bolts shall be of stainless steel.
- Enclosures shall be painted white (or as otherwise specified), with the Company rectifier number or identifier in 50 mm to 75 mm (2 in. to 3 in.) black lettering on the outside of the front cabinet door and equipped with a pad lockable draw latch, consisting of a heavy-duty, single-hasp draw latch.
- Either a pole-mounting bracket, or legs on the bottom (minimum length 600 mm [24 in.]) so it can be platform mounted, shall be provided and will be specified on the purchase order.
- Electrical panels shall be minimum thickness of 4.7 mm of (0.2 in.) NEMA Grade 'XX' phenolic. For panels greater than 100A, NEMA Grade UTR type shall be used.
- All electrical hardware shall be copper, or brass finished in electroless nickel plate. All connections shall be made secure with lock washers and nuts torqued in accordance with manufacturer's recommendations.

For all rectifiers, a flush-mount outdoor wall plate (Leviton part #4925-2) is to be installed. If possible, it is to be located on the bottom of the rectifier cabinet adjacent the closest side, or back wall, of the rectifier cabinet nearest the low-voltage interruption plug and adjacent to the 200 mm x 250 mm x 150 mm (10 in. x 10 in. x 6 in.) equipment bay. The access port shall have a hinged and environmentally sealed cover. The cover hinge shall also be spring loaded for closure.

The enclosure shall have the appropriate dimensions to accommodate an empty space for other equipment. The equipment bay is to be located on the bottom of the rectifier, adjacent to the access port described in the previous bullet. The free and clear dimensions of the equipment bay are to be 250 mm x 250 mm x 150 mm (10 in. x 10 in. x 6 in.). The equipment bay dimensions do not include the volume taken by the access port.

10.3 Transformer and Efficiency Filter Construction

Transformer and efficiency filter construction specifications are as follows:

- The transformer is to be designed as full isolation with separate and isolated primary and secondary windings, with a minimum efficiency of 95% at the maximum-rated voltage output.
- Transformer magnet wire and insulation materials are to be rated for CEC Class H (180°C) or NEC Class F (355°F), as applicable. Insulating materials shall be dipped in a thermosetting varnish and baked. Varnish shall meet or exceed the CSA requirements for Class H or NEC requirements for Class F operations, as applicable. Transformer voltage regulation shall not exceed 3% from full-rated load to no load.
- Dielectric strength of all insulating materials shall not be less than 2000 V RMS, as tested for one minute when applied between windings and the transformer core.
- The transformer shall be equipped with a minimum of 25 tap bar steps of secondary voltage adjustment (five coarse and five fine).
- Rectifier input overload and short-circuit protection shall be accomplished by magnetic circuit breakers; one pole per input line of AC power. Circuit breakers must trip at 140% of the rated AC input capacity of the rectifier. The input shall be labelled.
- Rectifier output overload and short-circuit protection shall be achieved by rectifier fuses in the transformer secondary of the rectifier. Rectifier fuses shall be sized for 120% rated transformer secondary RMS current. The output shall be labeled. (When the secondary fusing requirement exceeds 90 amps AC, the electronic Fuse Replacement Module will be considered as an acceptable alternative).
- Where specified, an efficiency filter (choke) shall be provided in the negative output of the rectifier. In the case of a multi-circuit rectifier, each circuit shall be provided with a choke, as mentioned. The choke shall be connected between the stack negative and the negative bus.

10.4 Instrumentation

Instrumentation specifications are as follows:

- The rectifier shall be equipped with multi-position switch(s) to connect a digital ammeter and voltmeter into each rectifier circuit, or pipeline negative lead. In addition, the multi-position switch shall have an "off" position that leaves the meter disconnected. The multi-position switch will also have a "lines" position, which activates a second switch that will connect each pipeline into the digital ammeter. In other words, two eight position rotary switches with the following settings:
    - Primary rotary switch – "Off, Circuit 1, Circuit 2, Circuit 3, Circuit 4, Circuit 5, Circuit 6 and Line" labels
    - Secondary line rotary switch – "Line 1, Line 2, Line 3, Line 4, Line 5, Line 6, Line 7, Bond" labels
- This configuration represents a case for a six-circuit rectifier connected to seven pipelines and one bond. Switch types and configurations may be varied according to the number of rectifier circuits, pipelines or bonds that must be metered. The off position for the primary switch shall isolate the ammeter and the voltmeter from any internal and external signal sources.
- The ammeter and voltmeter panel displays shall be high-intensity light emitting diode (LED) displays, with a minimum 13.2 mm (0.52 in.) digit height. All metered readings shall

maintain a displayed measurement accuracy to one decimal place (i.e., 0.1 V or 0.1 A). The ammeter shall have a minimum 3.5 digit display, and the voltmeter shall have a minimum four digit or 4.5 digit display. Both meters shall be auto-zeroing and auto-calibrating, during the manufacturer's initial setup. The required nominal voltage measurement range for the ammeter is ±199.9 mV (with the display scaled to the shunt ratings), and for the voltmeter it is ±199.9 V (displayed as measured).

- Both the ammeter and voltmeter shall have an accuracy of ±0.10% (or two counts) at 25°C (77°F). The drift in measurement accuracy shall not exceed ±0.50% at a temperature of -40°C (40°F). Test data documenting the accuracy of both the ammeter and the voltmeter over a -40 to +80 °C (40°F to175°F) temperature range shall be provided to verify the accuracy criteria outlined above. The Company shall approve the digital ammeters and voltmeters before purchase.
- The power supply for the high-intensity LED ammeter and voltmeter shall have a dedicated on/off switch, and a protective fuse installed downstream of the AC input surge arrestor for the rectifier.
- The 50A/50 mV metering shunts shall be the panel-mounted Holloway type SW style, with an accuracy of ±0.25%, where output currents are less than or equal to 50 A DC on any structure or rectifier circuit being measured. The Mobiltex, or manufacturer of other existing remote monitoring units (RMUs), can measure shunt voltages ± 158 mV. Where currents to be measured exceed 50 A DC, the provisions two bullet points below shall be used. For the digital ammeter, the following shunt sizes are compatible with the ammeter: 50 A/50 mV, 100 A/100 mV and 200 A/200 mV.
- Where line return currents or individual rectifier circuit outputs are less than, or equal to, 50 A DC, the shunts shall be 50 mV and sized for the maximum rectifier output current for negative drains, and shall be installed in each "line" negative output of the rectifier, including bonds. A separate 50 mV shunt, also sized for the maximum rectifier (single circuit) or circuit output (multi-circuit units) current shall be placed to provide metering for each different circuit's output. The shunt voltage shall be a negative common mode voltage for compatibility with the RMU.
- Where line return currents or individual rectifier circuit output currents exceed 50 A DC, two shunts shall be installed in series on each rectifier circuit or line return exceeding the 50 A DC limit. The first shunt installed shall be a 50 mV shunt, sized as previously outlined in this section, and shall be dedicated to the sense leads for the RMU pre-wire. A second shunt shall be installed downstream of the first, with a rating such that a minimum of 1 mV of voltage drop occurs across the shunt for each 1 A of current (i.e., 100 mV – 100 A shunt) to be measured by the high-intensity LED digital ammeter.

10.5 Terminals

10.5.1 Negative Output Terminals

When specified, all rectifier negatives, including those for multi-rectifier units, shall be bused together using removable shorting bars. The bars shall be placed after the choke (where applicable) on the negative side of the negative meter shunts on each circuit, and fed to one set of output terminals (lugs). The output terminals are to be labeled "Line 1," "Line 2." Output terminal lugs are to be sized to accommodate up to an AWG 1/0, unless otherwise specified.

10.5.2 Positive Output Terminals

Separate positive output terminals are to be provided with each circuit, and are to be labelled. The output terminal lugs are to be sized to accommodate up to an AWG 1/0, unless otherwise specified.

10.5.3 Bond Terminals

Terminals labelled "bonds" shall always be provided as specified on the purchase order, or Company standard drawings. Bond terminals are to be directly connected to the negative bus. Shunts for bond connections shall also be provided, if indicated on the purchase order, or Company standard drawings. Bond terminal lugs are to be sized to accommodate an AWG 1/0, unless otherwise specified.

10.5.4 Remote Monitoring Unit Pre-Wire

RMU pre-wire specifications are as follows:

- Optional, based upon site-specific requirements.
- All rectifiers requiring remote monitoring shall be pre-wired with sense cabling connected to a termination block
- Current measurement shunts (50 mV) for each rectifier circuit shall be located on the return side of each rectifier circuit to provide a negative common-mode voltage with the drain terminals. Sense cables shall be installed across each 50 mV shunt installed on the negative return for each rectifier circuit and negative line drains. These sense cables shall be labelled and terminated.
- As specified by the Company, voltage dividers shall be provided on sense cabling for each rectifier circuit to meet the specifications in Table 10-1.

Table 10-1: Voltage Divider Specifications

Rectifier Circuit Rating	Scaling Factor	RMU Metered Voltage into Pre-Wired Terminal Block
>150 V	10 : 1	0 – 20 V
0 – 150 V	1 : 1	0 – 150 V

- These dividers shall be installed in conjunction with the standard RMU pre-wire, as specified by the Company. If no voltage dividers are called for, then the sense cables are to carry rectifier circuit-line voltages, and are to be terminated.
- Sense cables shall be provided for all bonds to foreign structures, to measure both the bond current and the pipe-to-soil voltage on the foreign structure. In addition, the bond measurement facilities must ensure compatibility with the RMU. The channels allocated for measurement of bond currents and voltages shall have an option provided for full electrical isolation.
- If no electrical isolation devices are specified, then an empty terminal is to be left for the foreign structure sense lead (non-current carrying) and leave a blank terminal for a fixed reference cell lead. The 50 mV foreign structure current measurement shunt(s) shall be installed in series with the current carrying bond lead, and shall have sense leads terminated.
- Sense cables allocated to fixed reference cells must also ensure compatibility with the RMU.

- All sense cables shall be AWG 12 in size and have jacket materials compatible with the operation within the environment inside the rectifier cabinet. The sense cables, including jacket materials, shall be suitable for handling over a temperature range of -40°C to 105°C (-40°F to 220°F) ambient air temperature. A control transformer shall be installed in each rectifier unit for future power for the RMU5 remote monitoring device.

10.5.5 Low-Voltage Interruption Terminal

Low-voltage interruption terminal specifications are as follows:

- All rectifiers shall be wired with a CONXALL 4282-5SG-300 (including 4295 dust cap) 5-pin female connector. The wiring associated with the plug shall be AWG 20 TEW stranded copper cable rated to operate up to 105°C (220°F) temperature. Wire terminations for the connector are to be made as per Section 10.16.
- The CONXALL 4282-5SG-300 5-pin female connector shall be installed on the rectifier's front phenolic panel to allow the 4295 dust cap to have a minimum clearance of 51 mm (2 in.) from the rectifier cabinet door.
- The AC interruption relays shown in Table 10-2 shall be installed in parallel with the high-voltage twist-lock hubble connector across the interruption switch located on the L1 leg of the AC power supply wiring downstream of the AC surge suppressor (see Section 10.16).

Table 10-2: AC Interruption Relays

Rectifier AC Power Input Rating	AC Relays Types	AC Relay Model Numbers
0 – 50 A	Crydom Series 1	Model D2450-10
>50 A	Crydom Series 1	Model D24110-10

- All AC relays shall be installed with heat sinks appropriately sized to facilitate continuous operation of the AC relay under interruption.
- A Hammond BD2E 12 V power-supply transformer is to be installed to power terminals four and five on the CONXALL 4282-5SG-300 5-pin female connector. The input leads on the transformer are to be wired into the L1 AC supply lead, downstream of the AC surge suppressor, and the second lead is to be wired into the AC neutral (see Section 10.16).
- The wiring for the CONXALL 4282-5SG-300 5-pin female connector and the Crydom relays, as outlined previously in this section, shall be compatible with the Mobiltex CorrTalk Portable Interrupter Model SPI-1A, SESCO GPS timing device model TCMAD1-100, or SESCO GPS current interrupter model TCFAD1-100 in synchronously actuating the relays for pre-set GPS time-based interruption intervals.

10.6 Lightning Protection

Lighting protection specifications are as follows:

- Unless otherwise specified, metal oxide varistor arrestors shall be installed on both the AC input and the DC output of the rectifier.
- An arrestor shall be placed between the chassis and DC positive of each circuit, DC negative of each circuit and the chassis ground.

- Where semi-conductor or valve type arrestors are used, they are to be in an accessible location and enclosed in a small metal enclosure. The enclosure is to prevent fire in the event of a fault or surge.
- Arrestors are not to be mounted on the front control panel.

10.7 Inspection and Testing

10.7.1 Testing

All units shall be subjected to tests that verify that specifications are met. Documentation of these tests shall be provided.

10.7.2 Dielectric Strength Tests

Dielectric strength-test specifications are as follows:

- Every transformer shall be subjected to dielectric strength tests, conducted as per CSA C22.2 No. 107.1, or UL 60950, or NFPA 70, as applicable.
- Dielectric strength tests shall be conducted on the transformer before varnish dipping and baking, and after baking. The after baking test can be included as part of the final rectifier dielectric test.
- All assembled rectifiers shall be subjected to dielectric strength tests, as outlined in CSA C22.2 No. 107.1, or UL 60950, or NFPA 70, as applicable.

10.7.3 Inspection

After assembly, the rectifier shall be subjected to inspection of all wiring and mechanical components and their connections. Inspection shall also include over-all workmanship.

10.7.4 Operation

Rectifiers shall be subjected to testing and recording of all rectifier electrical parameters as follows:

- AC input voltage, current, apparent power and true power
- DC output voltage, current and power
- AC power factor
- AC to DC conversion efficiency

If a filter is required, the ripple at full output voltage shall be measured and documented.

Rectifier meters shall be tested to meet the requirements specified in Section 11.11.

10.8 Shipping

A rectifier identification plate shall be firmly attached on the inside of the cabinet door, and shall contain the following:

- manufacturer's name and code number
- AC volts and amperes
- line frequency
- number of phases
- DC voltage and ampere ratings

- ambient temperature rating
- serial number
- CSA file number (as applicable)

The following items are to be in a waterproof enclosure with documentation in the rectifier door, or if specified, labelled using lamacoid plates, or an equivalent approved by Company cathodic protection engineering personnel. Labels are to have a black background and white lettering.

- AC rectifier input terminals
- transformer tap positions (coarse and fine)
- negative and positive output lugs
- all meters
- switch positions
- main breaker
- DC and AC arrestors
- all fuses (size and type)
- interrupter mode switch
- interrupter receptacle
- utility receptacle
- high voltage (if applicable)

A circuit diagram and parts list shall be included with each rectifier. The rectifier drawing shall be laminated and mounted on the inside of the front door of the rectifier. In addition, a paper copy of the rectifier electrical schematic and a parts list for each rectifier detailing all of the components shall be provided to Company cathodic protection engineering personnel.

Each rectifier shall be individually packaged for shipment, and shall have the rectifier name or rectifier number clearly labeled on the exterior of the shipping box.

10.9 Rectifier Circuit Diagram

Refer to the Company standard drawings, or as per the Company's instruction.

11 THERMOELECTRIC GENERATORS

11.1 General Information

General specifications for thermoelectric generators are as follows:

- TEGs shall be designed to operate at temperatures between -45°C and 65°C (-50°F and 150°F).
- TEGs shall be designed to operate in unlimited rain or snowfall, provided that the unit is not flooded.
- TEGs shall operate in 100% relative humidity.
- TEGs shall operate in wind gusts of up to 140 km/h (85 mph).
- TEGs shall come complete with automatic re-ignition.

- All components shall be manufactured in modules, or assemblies for easy field maintenance.
- As necessary, the units shall be furnished with over-temperature protection circuitry.

11.2 Enclosure

Enclosure specifications are as follows:

- Enclosures shall be designed for outdoor installation, and be of stainless steel and aluminum construction.
- Enclosures shall be equipped with pad-lockable latches.
- All electrical hardware shall be copper, or brass finished in electrolysis nickel plate. All connections shall be made secure with lock washers and nuts, or with compression-type terminals.
- Enclosures shall be identified with the Company's rectifier number, or identifier in 50.8 mm to 76.2 mm (2 in. to 3 in.) black lettering on the outside of the front cabinet.

11.3 Mechanical Construction

Mechanical construction specifications are as follows:

- Units shall have a lead telluride solid-state, hermetically sealed power unit.
- Units shall have a nickel-alloy construction, meeker-type burner design that is stable in normal operating conditions.
- The individual TEG(s) shall be ordered to operate on butane, propane or natural gas, depending on the available fuel supply.

11.4 Metering and Instrumentation

Metering and instrumentation specifications are as follows:

- A separate suitably scaled voltmeter and ammeter as well as a current measuring shunt shall be provided to measure the DC output.
- Meters shall be a minimum 90 mm (3½ in.) size, with a minimum scale length of 73 mm (2⅞ in.).
- Metering accuracy shall be ±2% of full-scale deflection at 25°C (77°F). Temperature compensation shall be no more than 0.85% per 10°C (50°F), for temperatures other than 25°C (77°F).
- The package shall contain a terminal block capable of accepting 2/0 AWG (9 mm or ⅜ in.) cable.
- The package shall contain a variable resistor designed to control current output.
- Electrical output isolation from the chassis shall be achieved such that the leakage current does not exceed 100 mA.

11.5 Inspection and Testing during Manufacture

Inspection and testing specifications during manufacturing are as follows:

- All units shall be subjected to testing at 100% of rating.
- All units shall be subjected to tests as outlined in SPE-1000-94 for dielectric strength, bonding continuity, leakage current, stability and temperature.

- All units shall be subjected to testing and recording of all performance parameters as follows:
  - DC output voltage, current and power
  - DC input voltage, current and power
  - fuel pressure for rated power
  - set up voltage for rated power
  - leak test of fuel system
  - verification of ignition system operation

11.6 Shipping

An identification plate shall be firmly attached on the inside of the cabinet door, and shall contain the following:

- manufacturer's name and code number
- serial number
- fuel usage
- fuel pressure setting

12 SOLAR-POWER UNITS

12.1 General Information

General specifications for solar-power units are as follows:

- Solar-power units shall be as specified on the purchase order.
- The number of solar panels to deliver the requirements as specified in the purchase order, or Company standard drawings, shall be determined by the manufacturer or distributor.
- The size of the units (typically 12V DC or 24V DC) shall be specified on the purchase order, or Company standard drawings.
- All solar-power units shall have a main disconnect switch between the solar panels and the controller.
- All solar-power units are to be supplied with a silicon oxide varistor lightning arrestor with:
  - clamp voltage 100 V
  - maximum operating voltage 48V DC
  - maximum current 50 kA
  - maximum energy 750 Joules (0.7 BTU)
  - unlimited number of surges
  - 10 nanosecond response time

Solar-power units are also to be supplied with a system electrical ground lug.

12.2 Panels

Panel specifications are as follows:

- Solar panels shall be mounted on 12 m (40 ft) of Class 6 wooden utility poles.
- The diameter of the pole at the panel-mounting location is to be approximately 200 mm (8 in.).

- Mounting brackets to secure the solar panels shall be sized to accommodate attachment to the highest point on the utility pole.

12.3 Controllers

Controller specifications are as follows:

- Controllers shall be sized to accommodate the voltage and the current requirements as specified on the purchase order, or Company standard drawings.
- Controllers shall have a continuous voltage and current display.
- Controllers shall be housed in a water-tight enclosure with securable locking latches or handle.

12.4 Batteries

Battery specifications are as follows:

- All units shall be supplied with either absorbed glass mat (AGM) or gel-sealed batteries, as specified on the purchase order. The self-discharge rate of the battery must be less than 2% per month, and must have a 12-month warranty.
- Battery quantities and sizes shall be to provide a minimum of 72 hours autonomy, with no more than 50% depth of discharge.
- Batteries shall be housed in a separate insulated and vented battery box.
- The battery box is to have securable locking latches or handles. The battery box is to have mounting lugs to secure the box to a wooden platform, or platform approved by Company cathodic protection engineering personnel.

12.5 Enclosure

Enclosed specifications are as follows:

- Power centre enclosures must be rated as NEMA Type 3, 3R or 4, and are to be rain and sleet proof.
- The enclosures must have a drip shield over the door.
- The hinged door is to be sealed with seamless poured urethane gasket, and come complete with a lockable latching mechanism that maintain constant pressure on the gasket.
- The battery box shall be insulated with 50 mm (2 in.) high-density foam and sized to allow a 10 mm (½ in.) battery separation and be complete with a hinged lid with a lockable latch.

12.6 Shipping

The location to which the units are to be shipped shall be clearly marked.

13 TEST STATIONS

The test lead assembly shall be as per Company standard drawings.

14 REMOTE MONITORING EQUIPMENT

14.1 General Information

General specifications for remote monitoring equipment are as follows:

- All RMUs shall be CSA certified, or UL approved.
- All units shall have flash program memory.
- Internal components shall operate in the temperature range -40°C to +80°C (-40°F to +175°F).

14.2 Enclosures

Enclosure specifications are as follows:

- Enclosures for RMUs shall be NEMA 4X rated fibreglass or polycarbonate.
- Enclosures shall be equipped with a pad-lockable draw latch.
- All units are to be fitted with a CSA or UL approved (as applicable) 10 W heater and control thermostat to maintain the enclosure internal temperature within the radio's operating temperature range.
- Insulation shall be a "K" value suitable to allow a 10 W heater to provide the required minimum temperature.
- Insulation is to be rigid, foil backed non-hygroscopic and non-flammable to provide for a maintenance-free interior.
- The enclosure is to have a mounting plate supported over the insulation, for mounting components.
- A GPS antenna is to be mounted on the top of the enclosure and to be suitably sealed to prevent both the ingress of moisture and unnecessary heat loss.
- The external electronic temperature sensor shall be mounted off-centre on the bottom of the enclosure, and is to be suitably sealed to prevent both the ingress of moisture and unnecessary heat loss.

14.3 Channels

Channel specifications are as follows:

- All units to be equipped with 10 analog inputs and one interrupt drive output.
- All units shall have four isolated digital input points.
- All units shall have one internal (mounted on a PCB), and one external electronic temperature sensor.

14.4 Interruption

Interruption:

- shall be a solid state AC interrupt relay, 25 A at 280 VAC maximum
- is to occur via GPS time receiver

14.5 Communication

IMARSAT communication is to be via Easy Track Communication/GPS unit, with an operating temperature range of -30°C to +50°C (-22°F to 122°F).

14.6 Command Options

All units shall be able to indicate:

- AC power fail alarm. (Debounce timer set to 1 hour.)
- AC power restored. (Debounce timer set to 1 hour)
- DC power fail (DC current goes to zero, e.g. fuse fails or rectifier fails). (Debounce timer set to 1-hour.)
- Low battery (no time delay in sending this alarm).

14.7 Power Supply

Power shall consist of 120 VAC to 12 VDC supply for transceiver and electronics. (TEG version will be 24 VDC to 12 VDC.)

All units shall have a battery backup with charger and a low-voltage disconnect.

15 JUNCTION BOXES AND TERMINAL BOXES

15.1 Junction Boxes

Junction-box specifications are as follows:

- Junction box size and location shall be as per the purchase order or Company standard drawings.
- Junction box enclosures shall be cast aluminum, as per Wright Aluminum Ltd. specifications (Model# WAL-56 or Model# WAL-102).
- All junction-box enclosures shall have a high-voltage shield, and be mounted on 76 mm (3 in.) OD conduit(s), as per Company standard drawings.
- All junction boxes shall be constructed to CSA Enclosure 3R Classification, or equivalent.

15.2 Terminal Boxes

Terminal box specifications are as follows:

- Terminal box size and locations shall be as per the purchase order and Company standard drawings.
- Terminal boxes shall meet Hammond (Model 1418N4M8) or Bel (Model R363008) specifications.
- Terminal-box enclosures shall have a minimum sheet-metal thickness of 14 gauge.
- All steel terminal box enclosures shall be CEMA/NEMA 4 rated, and shall be powder coated (ASA61 grade polyester or ANSI/ASA61 grey baked recoatable enamel).
- Hinges and enclosure assembly bolts shall be stainless steel or aluminum. The enclosure shall be equipped with a latching device.
- All terminal box enclosures shall have a high-voltage shield, and be mounted on two 76 mm (3 in.) OD conduits as per Company standard drawings.

15.3 Panels

Junction box panels shall be a minimum thickness of 4.7 mm (0.2 in.) of NEMA Grade 'XX' phenolic.

All electrical hardware shall be copper or brass, finished in electrolysis deposited nickel plate. All connections shall be made secure with lock washers and nuts tightened to the manufacturer's recommended torque.

16 COPPER–COPPER SULPHATE REFERENCE ELECTRODES

Unless otherwise specified, all copper–copper sulphate reference electrodes shall be EDI Model UL - 30 Year LongLifeTM reference electrodes. Element type shall be a saturated gelled Cu/CuSO4. The lead wire shall be AWG 14 or larger, 15 m (45 ft) or greater in length, insulated in high molecular weight polyethylene, and rated for underground service.

Where specified, the CSCL copper–copper sulphate reference electrode shall be CPMP-2-50. The length of the cable shall be as per the site-specific construction drawings.

17 NOVAPROBES

NovaProbe specifications are as follows:

- Permanent NovaProbes are patented and only available from licensed manufacturers.
- Permanent NovaProbes shall measure the following parameters:
  - local soil resistivity
  - local soil pH
  - local oxidation reduction potential
  - "on" pipe-to-soil potential

18 COUPONS

Coupons shall be either 9 cm^2 or 50 cm^2 (1.4 in^2 or 9 in^2). Coupon test stations shall comply with Company standard drawings.

19 EXOTHERMIC WELDS AND BONDS

19.1 Thermite Welds

Thermite weld specifications are as follows:

- Thermite welds shall be a #15 gram charge (green cap) maximum with F-33 powder, or approved equivalent.
- A copper sleeve shall be used for wire sizes smaller than AWG 8. The sleeve size shall correspond to cable size.

20 PIN BRAZING

Pin brazing specifications are as follows:

- Pin brazing is acceptable application to attach test leads and bond wires (United States only).

- Reference the pin brazing equipment manual for the pin brazing techniques and surface preparation.
- Test for adequate bond and coat connection with approved coating.

21 SILVER SOLDERING

Silver soldering specifications are as follows:

- Use only 2% silver/98% tin soldier material with the appropriate flux.
- "Tin" the pipe and the conductor to be soldered.
- Heat the pipe and melt a solder puddle sufficient in size to attach the conductor.
- Test for adequate bond, and neutralize the acid flux with base solution.

22 MECHANICAL BONDS

Mechanical bond specifications are as follows:

- Circumferential clamp(s) is to maintain residual tension after the tensioning device is withdrawn. The cable connection to a circumferential clamp must be achieved by welding, or bolting to the clamping device.
- Any connection to structures, other than a pipe, must be achieved using materials required in the CEC or the NEC (as applicable) for grounding connections.
- Specially designed alteration to an electrical LB (elbow, back opens) fitting and connected to a flange bolt may be used. The apparatus shall be constructed of rigid conduit from a point 450 mm below grade and up to the LB. The cable shall pass through the conduit and connect to a lug inside the LB fitting. The conduit must be equipped with an EYS sealed fitting at the point of emergence from the ground.
- An alternative to the rigid conduit and EYS fitting is to use a single conductor Teck cable connected to the LB fitting with a "liquid tight" transition fitting.

23 CONTROLLED INTERFERENCE BONDS

A control device in an interference bond circuit shall consist of an appropriately sized resistor, or rheostat, and a meter or shunt.

24 AC MITIGATION, SURGE PROTECTION AND DC DECOUPLING

24.1 General Information

General specifications for AC mitigation, surge protection and DC decoupling are as follows:

- Isolation surge protectors shall be designed to simultaneously provide DC isolation and AC continuity at cathodic protection isolator locations, plus meet environmental ratings outlined in NEMA 4X and hazardous classifications for NEC, CSA: Class 1, Division 1 and 2, Groups A,B,C, D.
- Typical applications include installation where the facilities are subject to AC coupling, AC faults, or lightning, or electrical switching transients. Under AC faults or lightning (short-term transients) it is allowable for the device to temporarily conduct DC current.

- The device shall be designed to allow an unlimited number of switching operations (associated with occasional AC faults or lightning events) without failure.
- The ultimate failure mode of the device shall be in the closed-circuit position.
- The device shall be equipped with two-hole terminal pads for cable connection. The polarization cell replacement (PCR) device shall be equipped with two-hole (to accommodate ½ in. stainless steel bolts) terminal pads for cable connection. The solid-state decoupler (SSD) device shall be equipped with a single-hole (to accommodate 5/16 in. stainless steel bolts) terminal pads for cable connection.
- Isolation surge protectors shall be solid-state devices capable of normal operation at ambient temperatures between -45°C and +45°C (-50°F and 113°F).
- Ensure the PCR device meets the criteria for "an effective grounding path," as defined in Section 250.2 and 250.4(A)(5) of NFPA 70, and Section 10-500, 10-806 of CSA C22.1-12 (2012), and CSA C22.2 No. 0.4-04M1982 (R2009),and CSA C22.2-No. 213-M1987 (R2008).
- All DC decouplers shall be CSA certified, or UL approved.

24.2 DC Decouplers– Electronic Device Performance Characteristics

The performance characteristics of the DC decouplers (PCRs and SSDs) shall be specified by the following product ratings.

- lightning surge current
- voltage threshold
- 60 Hz fault current
- 60 Hz steady-state current
- enclosure
- instrument test feature
- special requirements

If not specified on the purchase order, the following parameters shall apply:

- Lightning surge current – 50 kA: This parameter specifies the minimum current that the device must be capable of passing while holding the voltage across the terminals below 700 V. The test waveform shall be 8 X 20uS.
- DC blocking voltage – -3/+1 V: This parameter specifies the upper DC voltage level, which will be blocked by the device while continuously conducting 60 Hz AC current.
- AC fault current: The magnitude and duration of fault current during a fault condition. The selected DC decoupler specification must meet or exceed maximum probable current and duration.
- Steady-state AC current at 60 Hz –45A RMS: This parameter specifies the maximum allowable steady state AC current that can be passed through the device while maintaining DC isolation.
- AC voltage drop under fault at 60 Hz ,<10 V ACrms: This parameter specifies the maximum AC voltage drop through the device under full rated fault current.

24.3 Enclosure

Enclosure specifications are as follows:

- Unless otherwise specified, the device shall be furnished with a NEMA 4X fibreglass-reinforced polyester enclosure suitable for outdoor non-submersible applications.
- The device shall be marked with the manufacturer's name, the device model number, the device serial number, and the month and year of manufacturer.
- UL or CSA certification shall be evident on the enclosure.

24.4 Instrumentation

The device shall contain a sufficient number and type of test terminals to allow AC and DC voltage and current measurements while in operation. All test terminals shall incorporate a dead-front design to prevent personnel from shocks, and shall be clearly labelled. Note: Separate test terminals are not provided. All tests can be conducted using the existing external bushing terminals. Even under the worst case, fault current rating for any decoupler model, the maximum voltage across the device terminals will be <10 VAC, well below the NACE maximum allowable voltage of 15 VAC. Consider adding DC decoupling devices that must be readily tested using standard field equipment, such as multi-meters and ammeters, and that manufacturers shall provide such testing instructions.

24.5 Shipping

The device shall be packaged for shipping to prevent damage.

- Refer to TED-CP-DD *Cathodic Protection Design Directive (CDN-US)* for application of the devices.

25 DELIVERABLES

- Material Safety Data Sheets
- Design Documents

26 QUALITY MANAGEMENT

26.1 Quality Checks and Documentation

The Company requires the following reviews before and during work:

- Review that the manufacturer is approved within the Company's approved vendor list.
- Review the materials adhere to the guidelines set forth in this specification.

The Company requires the following documentation before work starts:

- Verification of equipment calibration, as per equipment specifications.

26.2 Performance Measures

The manufacturer will be evaluated on the following measures:

- Adherence to the schedule – the ability to achieve milestones set forth by the Company.
- Delivery of materials – the materials are delivered to the Company in the timelines provided.
- Quality of materials – the materials adhere to the guidelines set forth in this specification.

26.3 Specification Deviations

When there is a request not to follow the specification as documented, an approved Management of Change is required. All deviations are to be reviewed and approved by the specification owner before the variance can proceed on the deliverable, data or report.

26.4 Noncomformance Management

All nonconformances to this specification will be reviewed by the Company and dispositioned by the vendor or manufacturer.

APPENDIX

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APPENDIX A APPROVED MATERIAL LIST

Table A-1: Approved Material List

Material Type	Manufacturer	Description	Model	Size (Metric)	Size (Imp)
Anodes	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2660	Length: 1524 mm Diameter: 66 mm Mass: 23 kg (nominal)	Length: 60 in. Diameter: 2.6 in. Mass: 50 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2684	Length: 2134 mm Diameter: 66 mm Mass: 31 kg (nominal)	Length: 84 in. Diameter: 2.6 in. Mass: 68 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	3884	Length: 2134 mm Diameter: 97 mm Mass: 31 kg (nominal)	Length: 84 in. Diameter: 3.8 in. Mass: 68 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2660Z	Length: 1524 mm Diameter: 69 mm Mass: 23 kg (nominal)	Length: 60 in. Diameter: 2.7 in. Mass: 50 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	2684Z	Length: 2134 mm Diameter: 69 mm Mass: 32 kg (nominal)	Length: 84 in. Diameter: 2.7 in. Mass: 70 lb (nominal)
	Anotec	High Silicon Chromium Chill Cast Iron Tubular Anodes c/w individual stranded AWG 8 stranded SPCP cable	3884Z	Length: 2134 mm Diameter: 76 mm Mass: 41 kg (nominal)	Length: 84 in. Diameter: 3.0 in. Mass: 90 lb (nominal)
		Graphite Centre Tap Anode	Varies depending on supplier	Length: 1016 mm Diameter: 102 mm Mass: 16 kg (nominal)	Length 40 in. Diameter 4 in. Mass: 35 lb (nominal)
		Graphite Centre Tap Anode	Varies depending on supplier	Length: 1524 mm Diameter: 76 mm Mass: 12 kg (nominal)	Length 60 in. Diameter 3 in. Mass: 27 lb (nominal)

Table A-1: Approved Material List (Cont'd)

Material Type	Manufacturer	Description	Model	Size (Metric)	Size (Imp)
		Graphite Centre Tap Anode	Varies depending on supplier	Length: 2032 mm Diameter: 102 mm Mass: 29 kg (nominal)	Length 80 in. Diameter 4 inch 64 lb
		Mixed Metal Oxide Anode	Varies depending on supplier	As specified on the purchase order.	As specified on the purchase order.

Table A-2: Approved MANUFACTURERS List

Material Type	Manufacturer	Model	Description – Above Ground Insulating Set	Description – Below Ground Insulating Set	Notes
Insulating flange gasket kit	GPT (www.gptindustries.com)	Pikotek VCS	• Type F gasket • G10 isolating retainer • Teflon or Viton seal • G10 isolating sleeve • Double Washer Set G10/ZPS washers	• Type F gasket • G10 isolating retainer • Teflon or Viton seal • G10 one piece isolating sleeves and washer sets or the G10 full length sleeves and single washer set configuration is required for below ground installations to allow the cathodic protection current to protect the nuts and bolts of the buried flange.	• Specify nominal pipe size, ANSI pressure class , temperature rating and media when ordering • ZPS - Zinc-Plated Steel Washers • When using the single washer configuration the isolating washer is placed against the flange, then the steel washer is placed next to the nut. Ensure the isolating washer is installed on the opposite side of the flange from TransCanada's CP system so the bolts can receive our CP current.
	GPT (www.gptindustries.com)	PSI Linebacker	• Type F gasket • G10 isolating retainer • Teflon or Viton seal • G10 isolating sleeve • Double Washer Set G10/ZPS washers	• Type F gasket • G10 isolating retainer • Teflon or Viton seal • G10 one piece isolating sleeves and washer sets or the G10 full length sleeves and single washer set configuration is required for below ground installations to allow the cathodic protection current to protect the nuts and bolts of the buried flange.	• Specify nominal pipe size, ANSI pressure class, temperature rating and media when ordering • ZPS - Zinc-Plated Steel Washers • When using the single washer configuration the isolating washer is placed against the flange, then the steel washer is placed next to the nut. Ensure the isolating washer is installed on the opposite side of the flange from TransCanada's CP system so the bolts can receive our CP current.

Figure A-1: Sleeve and Washer Configurations

Figure A-2: Single Washer Set for Below Ground Applications

Note: Double Washer Set for Above Ground Applications

Figure A-3: Double Washer Set for Aboveground Applications

Note: One isolation sleeve, two steel washers and two insulating washers for each stud/bolt.

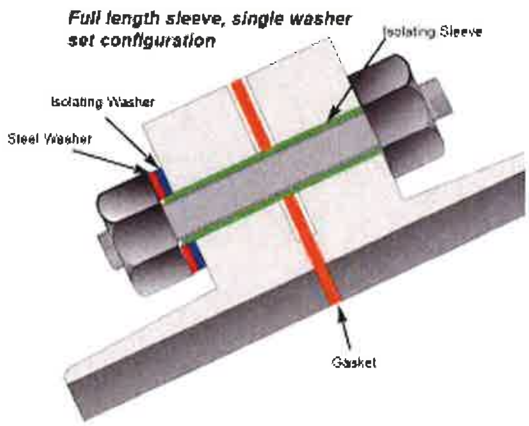

Figure A-4: One Piece Sleeve and Washer Sets for Below Ground Applications

APPROVALS

Originator: Swarandeep Sandhawalia Measurement Specialist EAR Measurement Engineering	Signature	May 15/2014 Date
Reviewer: Giles Brown, P.L.(Eng), C.E.T. EAR Measurement Engineering	Signature	June 30/2014 Date
Reviewer: Nathan Burgess, P. Eng. EAR Design Engineering Support	Signature	June 5, 2014 Date
Reviewer: Derek Chen, P. Eng. EAR Materials Engineering	Signature	May 29, 2014 Date
Reviewer: Jeff Cheong, P. Eng. EAR Electrical Engineering	Signature	MAY 22 / 2014 Date
Responsible Engineer: Chris Dennison, P. Eng. EAR Measurement Engineering	Signature 2014-July-7 Date	PROFESSIONAL ENGINEER CHRISTOPHER J. DENNISON ALBERTA REVIEW APEGA Permit to Practice P7100
Management Endorsement: Troy Pipella, Manager EAR Measurement Engineering	Signature	July 7, 2014 Date

SUMMARY

This Specification defines the Company's minimum requirements for the design, manufacture, testing, documentation, shipping preparation and supply of a natural gas Coriolis flow meter used for natural gas Custody Transfer applications in TransCanada. The Specification applies to all Company owned or operated natural gas custody transfer facilities in Canada, the United States, and Mexico.

DOCUMENT HISTORY

Rev. No.		
00	**Description**	**Effective Date**
	This is a new document.	2014-May-15
	Rationale Statement	**Responsible Engineer**
	This document defines the Company requirements for the use of Coriolis meters in Custody Transfer gas measurement.	Chris Dennison
	Impact Assessment Summary	**Team Owner**
	Training on document content for engineering service providers and current USTD drawings will require updating for complete alignment at the next release (when Rev 2 is released).	Measurement Engineering

BRIEF DESCRIPTION OF CHANGE

REGULATORY	
Section	**Description of Change**
	N/A
INDUSTRY STANDARDS	
Section	**Description of Change**
	N/A.
GENERAL	
Section	**Description of Change**
	This Specification is a new document.

DEVIATION FROM THIS SPECIFICATION

TransCanada Engineering Standards and Specifications must be followed by internal and external users to ensure a safe, reliable and technically correct design.

Deviations to this standard may be acceptable if a technical assessment approved by TransCanada Engineering & Asset Reliability shows that the deviation meets the intent of this specification, does not compromise safety and also complies with applicable industry standards, regulatory requirements and is consistent with sound engineering judgment.

Any deviation must follow the appropriate TransCanada management of change variance procedure.

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DEFINITIONS

Term	Definition
AGA	American Gas Association
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
Company	TransCanada
CSA	Canadian Standards Association
IP	Ingress protection
ISA	Instrument Society of America
Manufacturer	A company responsible for the development and production of equipment
MPMS	Manual of Petroleum Measurement Standards
NFPA	National Fire Protection Association
NPS	Nominal Pipe Size
Q_T	The flow rate above which the meter is functioning within its optimal range
Q_{MAX}	The maximum allowable flow rate through the meter
Q_{MIN}	The minimum allowable flow rate through the meter
SI	International System of Units
UPS	Uninterruptible power supply
UL	Underwriters Laboratories testing agency
VDC	Volts Direct Current
Vendor	Any outside source hired by the Company to complete work or supply material

1 PURPOSE

This Specification defines the Company's minimum requirements for the design, manufacture, testing, documentation, shipping preparation and installation of natural gas Coriolis flow meters used for Custody Transfer gas applications.

This Specification defines the Company's requirements to the equipment Manufacturer, Vendor or Engineer performing detailed engineering design.

2 SCOPE

This Specification applies to all natural gas custody transfer measurement facilities owned or operated by TransCanada in Canada, the United States, and Mexico.

3 REFERENCES

This Specification references documents listed in Section 3.1, 3.2 and 3.3; these documents shall be deemed part of this Specification and are mandatory requirements. This Specification only states the "highest level" relevant references. However, if any of the references cite other applicable documents, those documents shall be deemed part of this Specification. For example, CSA C22.2 is a mandatory requirement of CSA C22.1. However, this Specification only references CSA C22.1.

3.1 Regulatory Codes

- Canadian Standards Association (CSA) C22.1 *Canadian Electrical Code, Part 1*
- Industry Canada LMB-EG-08 *Specifications for approval of Type of Gas Meters and Auxiliary Devices*
- Measurement Canada, AG-0480 *Notice of Approval- Micro Motion Elite series*
- Canadian Standards Association (CSA) Z245.12 *Steel flanges*
- The American Society of Mechanical Engineers (ASME) B16.5 *Pipe Flanges and Flanged Fittings*
- National Fire Protection Association (NFPA) 70 *National Electrical Code*

3.2 Industry Codes and Standards

- American Gas Association Report No.11 *Measurement of Natural Gas by Coriolis Meter*
- American Petroleum Institute (API) Manual of Petroleum Measurement Standards (MPMS) Chapter 14.9 *Measurement of Natural Gas by Coriolis Meter*
- American National Standards Institute/Instrument Society of America (ANSI/ISA) 12.27.01 *Requirements for Process Sealing Between Electrical Systems and Flammable or Combustible Process Fluids*

3.3 Internal References

- TEP-QUAL-ESM-VAR *TransCanada Engineering Standards Variance Request Procedure (CDN-US-MEX)* (EDMS No. 006491847)
- TES-MATL-MD1 *Piping System Materials for Pipeline, Compression, and Metering Facilities* (EDMS No. 003764909)
- TES-MATL-MD1-US *Piping System Materials for Pipeline, Compression, and Metering Facilities Design to -50°F* (EDMS No. 004471280)
- TES-MATL-COMP Specification for the *Materials Requirements of Pressure Containing Equipment Components (CDN-US-MEX)* (EDMS No. 008071725)
- TES-PIPE-P8 *Specification for Meter Tube Pipe* (EDMS No. 003695410)

4 REQUIREMENTS

The meter shall be the industry standard product of a Manufacturer regularly engaged in the production of this type of equipment, and Measurement Engineering approved.

In addition:

- If the Vendor has any exceptions to the provisions of this Specification, the Vendor shall submit the exceptions in writing to the Company for approval.
- If the Vendor encounters conflicts between this Specification and other referenced documents, the Vendor shall inform the Company in writing and request clarification.
- If the Vendor does not understand requirements in this Specification, the Vendor shall request clarification in writing from the Company.
- Compliance with the requirements of this Specification does not relieve the Vendor of the responsibility to supply a suitably designed and manufactured meter for the intended service.

The Vendor shall have a certified quality program encompassing all aspects of design, fabrication, installation, commissioning and service provided to the Company.

The Vendor should be aware that manufacturing requirements may vary depending on the location where the meter is to be installed. These requirement variations may depend not only on country of installation but also jurisdiction within that country. This Specification will state different country requirements where applicable

4.1 Units of Measure

4.1.1 Measuring units and engineering information shall be stated in accordance with local custom and engineering practice;

- In Canada and Mexico, units shall be SI with the exception of those requirements stipulated by the codes and standards listed in this specification, and those stated in Section 4.1.2.
- In the United States units may be US Customary where applicable and shall comply with those stated in Section 4.1.2

4.1.2 All pipe and fitting sizes shall be nominal sizes (e.g. NPS 2, etc.) and tubing shall be outside diameter in fractional imperial units (e.g. ¾", etc.).

5 CIVIL AND STRUCTURAL

5.1 Design and Installation Requirements

5.1.1 The Meter location shall be chosen to provide easy access to the meter and transmitter.

5.1.2 The Coriolis meter installation shall be in an environment isolated from vibration.

5.1.3 The meter run piping on either side of the meter shall be supported in accordance with the manufacturer's recommendations.

5.1.4 Support members shall not be connected directly to the Coriolis meter unless explicitly permitted by the manufacturer.

6 MECHANICAL, MATERIALS, WELDING, AND COATING

6.1 Materials Requirements

6.1.1 The Vendor shall supply meter material suitable for the fluid and service conditions as specified in the equipment data sheet.

6.1.2 Meter run piping shall be designed according to TES-PIPE-P8.

6.1.3 Meter run materials shall be designed according to TES-MATL-MD1 for installations in Canada, and TES-MATL-MD1-US for installations in the US and Mexico.

6.1.4 Additional requirements are defined in TES-MATL-COMP.

6.1.5 Coriolis flow meter shall operate properly over a minimum ambient range of -40 to 60°C.

6.1.6 The vendor shall supply Material Inspection and Hydrotest certificate with the meter in accordance with TES-MATL-COMP.

6.2 Mechanical Design and Installation Requirements

6.2.1 Meter station piping shall be aligned before the meter is installed so that there is no torsion force or bending moment applied to the meter or meter run assembly by the station piping.

6.2.2 The Coriolis meter run shall be assembled together as one unit before connecting to the field piping section.

6.2.3 A minimum of 5 nominal diameters of straight pipe shall be installed upstream and downstream of the meter

6.2.4 No process connections are permitted within 3 nominal diameters upstream or downstream of the meter.

6.2.5 If reducers are required to match the internal diameter of the meter run piping to the meter, they shall be placed directly adjacent to the meter flanges.

6.2.6 The Coriolis meter shall be mounted with the measuring tubes above the plane of the meter run piping so that, liquids will not be allowed to gather in the oscillating tubes.

6.2.7 The station piping shall be designed using a minimum of NPS 2 pipe.

6.2.8 The Coriolis meter run shall be located between upstream and downstream isolation valves.

6.2.9 The meter run shall incorporate a downstream normally closed ball valve to depressurize the meter, referred to as the blown down valve.

- The blow down valve shall be closed with a plug if mounted outdoors or vented externally if mounted indoors.

6.2.10 The facility design shall facilitate the removal of the meter run for maintenance.

6.2.11 If the customer cannot tolerate a flow outage for routine maintenance then the design shall incorporate a bypass path around the meter.

- The bypass path shall be equipped with a block valve, which shall be locked in the closed position during normal operation.

6.2.12 If a filter/strainer is required, it shall be located upstream of the Coriolis meter and between the upstream and downstream meter run isolation valves to facilitate maintenance.

6.2.13 If required, pressure or flow limiting devices shall be installed downstream of the meter run.

6.2.14 The flowing velocity inside the Coriolis meter body tubing shall not exceed the manufacturer's stated limits.

6.2.15 Meter run piping velocity shall not exceed 21 m/s except within the meter body and adjacent reducers during normal operations.

7 TELECOMMUNICATIONS

7.1 Local Communication Links

7.1.1 The Coriolis meter or its associated transmitter shall accommodate local communication links via Ethernet or Serial MODBUS communications.

7.1.2 The meter shall provide a local operator means of communication for maintenance purposes that does not disrupt the functionality described in 7.1.1.

8 INSTRUMENTATION AND CONTROL

8.1 Process Connections

8.1.1 All Coriolis meter runs shall include threadolets for the following:

- Upstream Pressure Sensor – NPS ½
- Upstream Temperature Sensor – NPS ¾ on NPS 2, NPS 1 on larger piping.
- Spare – NPS ¾ on NPS 2, NPS 1 on larger piping.
- Composite Sample port for Composite sampler or Analyzer – NPS ¾
- Downstream Analyzer Sample / Spare – NPS 1
- Downstream Blow down – NPS 1

8.1.2 Pressure monitoring process connections and thermowells shall be installed upstream of the primary flowing direction of the meter and minimum of 3 pipe diameters upstream of the meter.

8.1.3 Fuel gas take-off connections shall be located outside of the meter run to ensure that the facility is supplied with fuel gas while maintaining the meter run.

8.1.4 For Canadian projects gas quality and composition monitoring sample probes and fuel gas take-offs shall be located on the pipeline side of the meter and not on the customer side of the meter.

8.1.5 For the US and Mexico projects gas quality and composition monitoring sample probes and utility gas take-offs shall be located as defined in the Project Design Basis.

8.2 Measurement Signal

8.2.1 All Coriolis meter installations shall interface with a Company standard flow computer capable of mass measurement calculations as defined in AGA Report No. 11.

8.2.2 All outputs should be isolated from ground and be protected against over-voltage events.

8.2.3 The Coriolis meter transmitter shall provide an uncompensated mass flow rate signal to the flow computer.

8.2.4 For custody transfer applications the Coriolis transmitter shall be configured to provide an open collector or equivalent pulse train to flow computer.

8.2.5 Where regulations permit and as defined in the project design basis, a serial or Ethernet signal incorporating mass flow rate may be used in lieu of the signal defined in 8.2.4.

8.2.6 The Coriolis meter transmitter may be configured with analog output representing uncompensated mass flow rate indication however this analog signal shall not be used for the purpose of custody transfer measurement.

8.2.7 If the measurement facility is designed for bi-directional flow, two separate frequency outputs or two separate registers in the transmitter shall be used, one for each flowing direction.

- Each frequency output shall only indicate in its designated flowing direction and shall be inactive in the opposite direction.

8.2.8 A no-flow cut-off value equal to 0.05% of sensor maximum flow rate shall be used that sets the flow rate output to zero when the indicated flow rate is below the set value..

9 ELECTRICAL

9.1 Electrical Supply

9.1.1 For Installation in Canada, the meter and transmitter shall meet CSA or equivalent testing requirements and approval shall be clear and permanently indicated on the equipment.

9.1.2 For installation in U.S. and Mexico, the meter and transmitter shall meet UL or equivalent testing requirements and approval shall be clearly and permanently indicated on the equipment.

9.1.3 The meter and transmitter enclosure shall be rated IP 65 or greater.

9.1.4 All Coriolis meters shall be powered by a UPS backed 24 VDC power supply.

9.1.5 The meter and transmitter electronics shall be isolated from ground such that they operate on a floating power supply without causing a ground fault.

9.1.6 The meter and transmitter shall be suitable for installation in Class 1 Zone 1 Group IIA hazardous location.

9.2 Wiring Methods

9.2.1 The meter interconnection wiring shall comply with the electrical area classification in which the meter is installed.

10 CORIOLIS METER AND TRANSMITTER REQUIREMENTS

10.1 Meter Requirements

10.1.1 The Vendor shall supply a meter meeting the requirements stated in Table 10-1.

Table 10-1: Meter Performance Requirements

PARAMETER	DESCRIPTION
Meter Principle	Coriolis
Mass Flow Rate Accuracy	±0.35% of flow rate between Q_T and Q_{MAX}
Turndown	Vendor shall define meter turndown within +/-0.5% uncertainty limit.
Mass Flow Repeatability	±0.20% of flow rate between Q_T and Q_{MAX}

10.1.2 The meter's minimum flow rate Q_{MIN} is defined by the maximum permitted uncertainty of ±0.5% over the expected flow range of the meter.

10.1.3 The meter's maximum flow rate, Q_{MAX} is defined by the manufacturer recommended maximum allowable gas velocity of 120m/s through the meter.

10.1.4 Coriolis meters shall be sized using the manufacturer's recommended sizing tool.

10.1.5 The Coriolis meter shall be calibrated by an approved calibration facility at Q_{MIN}, 2.5%, 10%, 25%, 50%, 75% and 100% of Q_{MAX}.

10.1.6 Fixed value for pressure compensation shall be used if the calibration pressure is different from operating pressure.

10.1.7 All openings on the meter shall be securely plugged and the meter and transmitter shall be packaged prior to shipping to mitigate handling damage.

10.1.8 The maximum rate factor (scaling factor) for each size of Coriolis meter is based on the Maximum Operating pressure, Minimum Operating temperature and maximum allowable velocity of 120m/s through the meter.

Note 1: The maximum scaling factor values applicable to Canada are as per Measurement Canada Notice of Approval **AG-0480**

10.2 Transmitter Requirements

10.2.1 The Transmitter shall be supplied with Measurement Canada approved Firmware/Software.

10.2.2 The Vendor shall supply transmitters with Weights and Measures features enabled.

10.2.3 In Canada, Custody transfer installations at high intervention sites shall be sealed by a Measurement Canada Representative.

10.2.4 Installations at Low intervention sites in Canada and all sites in US and Mexico do not require sealing.

10.2.5 All configurable parameters shall be stored in non-volatile memory.

11 DOCUMENTATION REQUIREMENTS

11.1 Documentation Required with Quote

11.1.1 The Vendor shall submit documentation to the Company for approval prior to manufacturing of meter. As a minimum, the Vendor shall submit the following information with the quote:

- list of any exceptions to this Specification
- meter outline and bore dimensions
- pressure drop calculations across the meter at maximum operating viscosity, minimum operating temperature and maximum flowrate
- sizing calculation
- proposed production schedule

11.2 Documentation Required Post-Award

11.2.1 After testing, the Vendor shall update drawings with any changes required by testing and submit to Company.

11.2.2 As a minimum, the Vendor shall submit the following documentation post-award:

- Factory Calibration report
- Completed data sheets
- Documents stated in TES-MATL-COMP
- Equipment installation, operating and maintenance manuals
- Vendor Drawings

12 CONFLICTS, SUBSTITUTIONS, EXCEPTIONS OR DEVIATIONS

The Vendor is responsible to ensure that all materials comply with the requirements of this Specification and shall not make any substitutions without the prior written approval of the Company. However, any such approval will in no way relieve the Vendor of full responsibility of the adequacy of all materials provided.

TES-ME-CV-GL Control Valve Equipment and Design Specification (CAN-US-MEX)		TransCanada In business to deliver

EDMS No.: 1001969647	Rev.: 00	Status: Issued	Effective Date: 2016-Dec-01
			Next Review Date: 2018-Dec-01

PURPOSE

This Specification provides the design and material requirements for selecting control valves, and also addresses the installation requirements of control valves for use in natural gas and liquid hydrocarbon services .This specification applies to all control valves used in Canada, the United States, and Mexico.

SCOPE / APPLICABILITY

Within this Specification, TransCanada is referred to as the Company.

This Specification applies to:

- Control valves used in the Company's liquid pipelines and related facilities.
- Control valves used in the Company's natural gas pipelines and related facilities.

Within this Specification, the following terms and definitions apply for requirements:

- Shall—expresses a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard. Shall is not a recommendation but a requirement.
- Should—expresses a strong preference, recommendation or that which is advised, but not required.
- Must—denotes a requirement of the Company, for which no deviation or variance would be granted.
- May—expresses an option or that which is permissible within the limits of the standard.
- Consider—assumes that a competent person will evaluate options to fulfill the intent of the requirement and make a documented decision supported by evidence to ensure protection of people, equipment and the environment by achieving the appropriate level of functional integrity.

Wherein the Manufacturer's literature, governmental or regulatory requirements conflict with this Specification, the more stringent requirement shall govern.

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1 GLOSSARY

Actuator

A pneumatic, hydraulic, or electro-hydraulic device that supplies force and motion to open or close a valve

API

American Pipeline Institute

ASME

American Society of Mechanical Engineers

ASTM

American Society for Testing and Materials

Ball Valve

A valve with a spherical disc to control flow; the sphere has a hole or port, which, depending on the alignment, allows flow.

CFR

Code of Federal Regulations

CSA

Canadian Standards Association

Cavitation

Cavitation is very similar to flashing, but with one exception; the fluid pressure recovers to a pressure that is above its vapour pressure. This causes the previously formed vapour cavities to implode, producing impinging jets that have the potential to cause severe erosive damage. This type of damage is marked by rough gouges in material. (Definition from Fisher Controls)

Control valve

A valve used to control conditions such as flow and pressure by fully or partially opening or closing in response to signals. The signals are received from controllers that compare a *set point* to a *process variable*; this value is provided by sensors that monitor changes in such conditions.

dBA

A-weighted decibels are an expression of the relative loudness of sound, in air, as perceived by the human ear.

FCI

Fluid Controls Institute

Flashing

Occurs when the pressure of a fluid falls below its vapour pressure, changing from a liquid to a vapour. During this process, small vapour cavities form that grind away at the outlet of the control valve and its trim components. Flashing damage is marked by shiny, smooth gouges in material. (Definition from Fisher Controls.)

Flow coefficient (Cv)

A constant related to a valve's geometry for a given travel and can be used to establish flow capacity. Cv=1 is the amount of water at 60°F (15.6°C) in US gallons that flows through a valve per minute with a 1 psi (6.9 kPa) pressure drop.

Globe valve

A valve with a linear motion closure member, one or more ports, and a body distinguished by a globular cavity around the port region.

ISA

International Society of Automation

Jam-Nut

A nut used to jam and lock another nut securely in place; the second and locking nut on a stud bolt. After the first nut is threaded and tightened on a stud, a second nut is tightened down on the first nut to prevent it from working loose.

Positioner

Positioners typically move a control valve to a specified position so a process meets specific parameters (flow, pressure and temperature).

Trim

Trim refers to all internal process wetted components. Trim includes the valve plug, the valve plug stem, the cage and the seat ring.

ANSI/ISA 75.05.01-2000 defines trim as "*the internal components of a valve that modulates the flow of the controlled fluid*."

2 DESIGN REQUIREMENTS

2.1 Required Process Conditions

The following process conditions shall be collected before the control valve selection process begins.

2.1.1 Gas Service

- Gas properties, e.g., specific gravity, composition, and water content
- The control valve shall pass the minimum design flow at no less than 10% of valve travel, or as recommended by the Vendor. The maximum design flow shall be no greater than 80% of valve travel (for throttling conditions) and 100% for full flow, or as recommended by the Vendor.

2.1.2 Liquid Service

- Fluid properties, e.g., liquid density, viscosity, critical pressure and vapour pressure (at selected conditions);
- The control valve shall pass the minimum design flow at no less than 20% of valve travel, or as recommended by the Vendor. The maximum design flow shall be no greater than 80% of valve travel, or as recommended by the Vendor, and 100% for full flow, or as recommended by the Vendor.

2.1.3 Common for Liquid and Gas Services

- Temperature of the fluid (minimum, and maximum); (T_{min}, T_{max})
- Flow rate (minimum, normal and maximum); (Q_{max}, Q, Q_{min})
- Inlet pressure at the valve (minimum, normal and maximum); (P_{1min}, P_1, P_{1max})
- Outlet pressure at the valve (minimum, normal and maximum); (P_{2min}, P_2, P_{2max})
- Class shutoff (leakage classification Class IV or better)
- Inlet and outlet pipeline size and wall thickness; (D_i, D_o, t)
- Preferred valve type, if known, ball or globe
- For certain process flow conditions, axial flow control valve may be used
- Maximum permissible noise level (dBA)

2.2 Control Valve Applications

- If the required range of process conditions is too large for one control valve, two or more control valve regulation runs might be required to operate in a split-range mode or parallel mode. In some applications, a monitoring control valve can be installed in conjunction with a working control valve in a single regulation run also known as a working/monitoring installation.

- Typically ball valves are selected for high capacity volumes whereas globe valves are selected for high pressure cut applications.

2.3 Determine Process Conditions for Sizing

2.3.1 The following process conditions shall be assumed:

- Q_{max}: P_{1min} and minimum pressure drop, conditions for the largest flow coefficient (C_v)
- Q_{min}: P_{1max} and maximum pressure drop, condition for the smallest C_v
- Q_{max}: P_{1max} and maximum pressure drop, condition for loudest noise
- Q_{max}: P_{1min} and minimum pressure drop at 100% open (if different C_v than condition No. 1)
- Normal operations, the condition the valve operates in most of the time.

2.3.2 Future design conditions shall be known and considered. This allows for the consideration of increased flow, when sizing the control valve. For example, if a globe control valve is selected, then a reduced trim may be appropriate, with the possibility of changing to a larger trim in the future. If a different style of valve is suitable for the required service conditions, the Vendor may offer it as an option. Conversely, an alternative way to size a control valve is to use an iterative process where preliminary C_v is calculated. Noise and cavitation calculations are then carried out to verify that the C_v provides acceptable noise and cavitation as specified by the project data sheet.

2.3.3 If the existing design has significantly changed from the original design and has caused noticeable changes in vibration, noise level, or wall thickness reduction due to erosion, then a design review shall be required.

2.3.4 The control valve shall be designed to operate within the range of operating fluid temperatures outlined on the data sheet, confirming that the ambient temperature of where the valve is installed falls within that range. Typically, control valves are ordered for -45°C or -29°C (-49°F or -20°F) ambient temperature; the temperature dictates the type of material from which the control valve body should be made.

2.4 Sizing Calculations

2.4.1 Common for Liquid and Gas Services

- Designers shall perform sizing calculations and verify the Vendor's calculations, as required.
- The Vendor shall identify the method of valve size calculation.
- The Vendor shall perform and provide sizing calculations at various operating conditions, as indicated on the data sheet supplied by the Company, as per section 2.1.

- The Vendor shall supply computer-generated sizing data sheets, based on *ISA S75.01.01* or the Vendor's sizing program.

2.4.2 Liquid Service

- The valve shall not cavitate or flash throughout its required process conditions.
- The Vendor shall recommend any special materials, valve construction, or special trim required to prevent cavitation or flashing.

2.5 Noise Calculations

- The Vendor shall ensure the maximum sound level does not exceed 85 dBA, and 90 dBA for unmanned facilities at a distance of 1 m (3 ft.) downstream/upstream and 1 m (3 ft.) above the pipe from the valve. Any exceptions shall require the written approval of the Company.

  Note:
  NOM-081-SEMARNAT-1994 requires that Mexican facilities maintain a noise level below 65 dBA at the facility's fence limit during normal operating conditions. The Designer shall indicate in the data sheet the valve's maximum noise level at 1 m (3 ft.) distance from the valve to comply with the requirements of *NOM-081-SEMARNAT-1994*, based on noise calculations and the fencing location relative to the control valve.

- The lower noise levels shall be maintained in locations where a minimum noise level is required at a nearby property line. Other means of attenuation may be required, such as thicker pipe, larger pipe, or acoustic insulation.
- The Vendor shall provide noise design calculations for the process conditions provided on the datasheet for review and approval.

2.6 Valve Type Selection

2.6.1 The sections below outline the characteristics of control valve options. The following ball valve characteristics shall be considered:

- good for flow control
- less useful for large pressure drops
- less pressure drops across the valve at 100% open, therefore it is useful for free-flow (no restriction) applications
- greater capacity for a given valve size
- available with noise and cavitation trim for **Liquid Service**
- available with noise attenuation trim for **Gas Service**
- produce greater noise at a higher pressure drop (compared to globe valves)

2.6.2 The following globe valve characteristics shall be considered:

- lower capacity for the same nominal size compared to the same size ball valve
- mainly used for continuous throttling applications
- good for large pressure drops over long durations
- available with noise and cavitation trims for **Liquid Service**
- available with noise attenuation trim for **Gas Service**
- greater noise reduction capability than ball valves

2.6.3 The following axial flow valve characteristics shall be considered

- good for flow control
- less useful for large pressure drops
- At 100% open, pressure drop will be greater than a ball valve
- At less than 20% open, control stability issues and high noise may be encountered
- greater capacity for a given valve size
- available with noise and cavitation trim for **Liquid Service**
- available with noise attenuation trim for **Gas Service**
- produce greater noise at a higher pressure drop (compared to globe valves)

2.7 Trim Type and Material Selection

2.7.1 The required process conditions shall be considered (see sections 2.1, 2.2 and 2.3) when selecting trim materials to ensure that the trim will function properly and withstand its operational requirements. Normally, Vendors are consulted for recommendations regarding the trim material.

2.8 Leakage Requirements

2.8.1 The seat leakage classification shall be for control valves is Class IV or better, as defined in *ANSI/FCI 70-2*.

2.8.2 A seat leak test is required as per *FCI 70-2,* unless specified on the datasheet supplied by the Company.

2.9 Hydrostatic Testing Requirements

2.9.1 All control valves shall be subjected to shell hydrostatic pressure test in accordance with the TES-MATL-COMP (EDMS No. 8071725) except in Canada due to the required longer test duration.

2.9.2 All control valves in Canada shall be hydrostatically tested to a minimum of one-hour shell test, either within the manufacturing facility (preferred) or a fabrication facility.

2.9.3 The minimum shell test pressure shall be 1.5 times the rated cold working pressure.

2.9.4 There shall be no leakage for the duration of the pressure test and no permanent distortion as a result of the pressure test.

3 ACTUATOR AND ACCESSORIES

3.1 Actuators

3.1.1 Liquid Service

- The control valves shall be equipped with electro-hydraulic actuators, for most of the applications. The designer, in consultation with Electrical Engineering, shall define the electric requirements for the electro-hydraulic actuator (available AC voltage level, frequency, available DC voltage level, etc.). This shall be incorporated in the data sheet issued by Company. The Vendor shall complete the data sheet (required power etc.) and return it to company.
- The time required to actuate the valve shall be determined and noted on the datasheet.

  Note:
  In previous liquid pipeline systems, the time required to actuate the valve fully has been limited to a maximum of 10 seconds. However, this is only a guideline from previous projects. The stroking time should be determined in consultation with System Design in conjunction with a transient hydraulic analysis, and will be indicated on data sheet.
- Electro-hydraulic actuators shall be used for fine and rapid positioning requirements involving the control of pipeline pressure and flow rates, as well as situations where a certain valve fail position is required.
- Electro hydraulic actuators shall be designed to provide its rated torque within +/-10% of nominal voltage
- The following additional requirements shall apply:
  - Neutral position shall be clearly indicated. The actuator shall be capable of stroking the valve in increments of 15% of full stroke.
  - The hydraulic circuit shall be totally self-contained and require minimum maintenance.
- The Vendor shall ensure the tag number, the manufacturer, and the model number is provided on the datasheet. The Company specifies the tag number.

3.1.2 Gas Service

- The actuator shall be air or gas operated, as specified in the data sheet.
- The pneumatic actuators shall be used for fine and rapid positioning requirements involving the control of pipeline pressure and flow rates, as well as

situations where a certain valve fail position is required. The pneumatic actuator shall be either spring opposed diaphragm or double acting piston.

- The Vendor shall size the actuator with consideration of flow, gas properties and operating conditions, as described in Section 2.1.
- Actuators shall be designed to fail close, or fail open, or last position on loss of pneumatic supply and open or close on loss of signal. Actuators may be reverse or direct acting. Required Failure position on loss of supply or signal shall be indicated on the data sheet.
- The Vendor shall ensure the tag number, the manufacturer, and the model number is provided on the datasheet. The Company specifies the tag number.

3.1.3 Common for Liquid and Gas Services

- All necessary components and hardware to adapt and mount the actuator to a bare stem shall be supplied by the Vendor.
- Actuators on ball valves shall be mounted on the left or right-hand side of the control valve when looking downstream. Actuators on globe valves shall be vertically mounted. The Designer shall confirm the position with Field Operations and indicate it on the datasheet, to be issued by the Company.
- The valve actuators shall be sized for 1.2 times the maximum valve torque requirements, and be approved by the Company. The additional torque requirements will ensure that the valve can be actuated quickly without risk of damage to the actuator.
- The Vendor shall ensure that actuators are designed to fail in the position as specified on the data sheet.
- The Vendor shall consider stroking time, if indicated in the data sheets for actuator selection.
- The control valve shall be supplied with the actuator already mounted.

3.2 Control Valve Accessories

3.2.1 Signal Transducer (I/P)

- The signal transducer, when selected, shall provide an output of 4 mA to 20 mA to indicate a range from fully closed to fully open (or vice versa).
- The manufacturer, model, type, supply pressure, signal action (direct or reverse), and valve position at outputs of 4 mA and 20 mA shall be recorded on the datasheet.

3.2.2 Positioner and Controllers

- Valve positioners (if requested) shall be provided on control valves, as specified in the data sheet issued by the Company.

- The tag number, manufacturer, model, type and signal action of the positioner shall be recorded on the completed data sheet.
- The indicator pointer shall be directly connected to the stem or shaft. The valve position shall be indicated on reversible scale with clearly graduating marking at 25% valve opening position intervals and labelled with the words Open and Closed at the valve's travel limits.
- Pneumatic valve positioners shall be provided with gauges to indicate supply pressure, control signal and positioner output pressure.
- Electro-pneumatic valve positioners and pneumatic valve positioners with integral electro-pneumatic transducers shall not be used in potentially vibrated service if they are mounted on the control valve. The I/P transducer shall be mounted separately from valve and actuator assembly. Where possible, digital valve controller positioners (e.g., DVC, DNGP, PMV Controllers) should be used, as they offer stable control and diagnostic capabilities.
- The total maximum inaccuracy of the signal conversion in I/P, due to any limitations, shall be less than 2%.
- Natural gas operated control valve actuators / positioners / controllers shall be equipped with quarter inch NPT connections (minimum) that would allow gas bleeds to be piped outside of classified buildings.
- Low bleed natural gas operated positioners / controllers shall be given preference over high bleed pneumatic positioners / controllers.

3.2.3 Position Transmitter

- The position transmitter shall be provided, if requested on the data sheet. The position transmitter shall provide position indications from 0% to 100% of valve travel, or 0 to 90 degrees of ball valves openings.
- The Indication shall be a linear 4 mA to 20 mA from the valve fully closed to fully open position, or vice versa.
- The manufacturer, model, type, mechanical link (rotation, direction, cable or magnetic) and valve position at outputs of 4 mA and 20 mA shall be recorded on the data sheet.

3.2.4 Solenoid Valve

- If a solenoid valve is required, the Designer, in consultation with Automation Engineering, shall determine the following solenoid valve features:
  - power supply
  - de-energized state (valve open, valve closed)
  - energized state

3.2.5 Limit Switches

- When required, limit switches are double pole, double throw proximity type and hermetically sealed as specified in the data sheet. Two single-pole, double-throw switches can be substituted for each double pole, double throw switch.
- Limit switches, at a minimum, shall be rated for 2 Amps at 24 Voltage Direct Current (VDC).
- Limit switches shall be actuated by a mechanical switch or proximity sensor.

3.2.6 Travel Stop

- When travel stops are required, the adjustment shall be lockable or be equipped with a jam-nut arrangement. Travel stops are rarely required.

4 VALVE-SPECIFIC REQUIREMENTS

4.1 Ball Valve

4.1.1 The Vendor shall ensure that ball valves meet the following criteria:

- Ball valves shall be of raised face flanged end or flangeless raised face design.
- The seat ring and seal joint area of the ball, or segmented ball, shall be designed for continuous throttling control of the process service.
- Stem seals shall be resistant to vibration
- Ball valves shall have trunnion-mounted balls and blowout proof stems.
- Ball valves shall be supplied with noise attenuation trims or cavitation trims **(Liquid Service)**, if required.
- In some applications, bi-directional flow may be required. In these situations, the valves shall be equipped with dual seats that will preclude leakage in either direction.

4.2 Globe Valve

4.2.1 The Vendor shall ensure that globe valves meet following criteria:

- Globe valves shall be flanged-end, unless otherwise specified on the data sheet
- Stem seals shall be resistant to vibration.

If a noise trim is required, the size of the openings in the trim should be greater than 6 mm (1/4 in.), to allow passage of debris (e.g., welding slag) without getting caught in the holes and causing damage to the cage. Larger trim openings have not been shown to significantly increase valve noise

5 MATERIAL REQUIREMENTS

5.1 Material

5.1.1 The following material requirements shall be considered:

- The valve materials, including body and bonnet, shall be in compliance with TES-MATL-COMP (EDMS No. 8071725) requirements and compatible with the conditions specified in the data sheet.
- Trim materials shall be selected to withstand corrosion, erosion and wear under severe service conditions. Material combination shall be selected for maximum galling resistance.

  Note:

  Typically, valve bodies are made of carbon steel such as *ASTM A350 LF2* or *ASTM A352 LCB/LCC*. For 50 mm (2”) and smaller control valves, *ASTM A216 WCB* or *WCC* is acceptable.

5.1.2 The Vendor shall supply a stainless-steel nameplate and permanently fasten it to each valve body, as per the requirements of TES-MATL-COMP (EDMS No. 8071725).

5.1.3 The Vendor shall ensure that all control valves have flanged-end connections, unless otherwise specified in the data sheets.

5.2 Flow Direction

5.2.1 The primary flow direction shall be indicated on the valve body, or alternatively, a stainless-steel arrow shall be permanently fixed to the body.

5.3 Packing

5.3.1 Packing shall meet the requirements of the process conditions, and should be based on Vendor’s recommendations.

5.4 Bolting

5.4.1 The Vendor shall recommend bolting materials for the particular conditions. Typically, studs are made to *ASTM A320 L7* and nuts to *ASTM A194 Gr. 4 or 7*.

5.4.2 The Vendor shall ensure that, if special bolting is required for the control valves, they are supplied. Rolled thread bolts shall be supplied for flange insert control valves.

6 INSTALLATION REQUIREMENTS

6.1.1 Control valves accessories, at a minimum, shall be designed for Class 1, Division 2 areas.

6.1.2 If the control valve is being installed outdoors, site-specific consideration shall be given to ensure that it is weather proof and properly covered/protected. Typically, some type of enclosure should be installed to protect the control valve.

6.1.3 Control Valves in Liquid Service

- Control valves in liquid service shall not be installed below ground.

6.1.4 Control Valves in Gas Service

- Control valves in gas service may be installed below ground; however, they can be flanged or welded connections. The Company preference is flanged connections in below ground applications.

7 DOCUMENTATION

7.1.1 Upon receipt of the order, the Vendor shall supply an authenticated copy of the sizing calculations and completed data sheets for the Company's review and approval.

7.1.2 The Vendor shall provide certified drawings for review and mill reports or mill test reports to the Company upon delivery of the valve.

7.1.3 As a minimum, documentation submitted by Vendor shall include:

- Capacity (C_v) as function of travel; confirmation by the Vendor that the required range-ability can meet with proposed control valve.
- Noise calculations, including the calculation basis and results for each specified flow condition.
- Vendor should also specify body and trim exit fluid velocity expressed in m/s (ft/s) and sonic (Mach).

7.1.4 Additional items required at the time of delivery:

- Actuator load calculations for the control valve
- Hydrostatic test report
- Seat leakage test report, if performed
- Stroke performance test report

8 VARIANCES

Any deviation shall follow the TransCanada Management of Change (MOC) Variance Procedure (EDMS No. 7728702). External Vendors shall contact the TransCanada Project Engineer for variance approval.

9 ROLES AND RESPONSIBILITIES

Table 9-1 below outlines the roles and responsibilities required for the use of this Specification.

Table 9-1: Roles and Responsibilities

Role	Responsibilities
Design Engineer/Designer	The Design Engineer is responsible for the design of the control valve and for ensuring the control valve is design in accordance with applicable codes, standards, and regulations. Design Engineers may be from the Company or from an external engineering company.
Vendor	Control valve manufacturer or provider of the control valve – also those who have been contracted to supply valves, which also include their manufacturing facilities and sub-vendors.
The Company	TransCanada, its corporate affiliates or its agents.

10 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are detailed below in Table 10-1. Use the latest document revision, unless otherwise approved by TransCanada.

Table 10-1: External and Internal References

Document No.	Title
Regulatory Codes	
SOR/99-294	National Energy Board Onshore Pipeline Regulations
CFR Title 49 Part 192	Transportation of Natural and Other Gas by Pipeline
CFR Title 49 Part 195	Transportation of Hazardous Liquids by Pipeline
SOR/86-304	Canada Occupational Health and Safety Regulations
NOM-007-SECRE-2010	Transporte de Gas Natural
NOM-081-SEMARNAT-1994	Que establece los límites máximos permisibles de emisión de ruido de las fuentes fijas y su método de medición.
Industry Codes and Standards	
National Fire Protection Association	National Fire Protection Association
CSA Group (CSA) – Concrete materials and methods of concrete	CSA Group (CSA) – Concrete materials and methods of concrete
American Pipeline Institute (API) Spec 6D	Specification for Pipeline and Piping Valves

Document No.	Title
American Society of Mechanical Engineers (ASME) B16.47	Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard
ASME B16.5	Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard
ASME B31.4	Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids
ASME B31.8	Gas Transmission and Distribution Piping Systems
American Society for Testing and Materials (ASTM) A216	Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service • WCB or WCC (-29°C or -20°F)
ASTM A352	Standard Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service • LCB or LCC (-46°C or -50°F)
ASTM A350	Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components • LF2 and LF3 (-45°C or -49°F)
Canadian Standards Association (CSA) Z245.12	Steel Flanges
CSA Z662	Oil and Gas Pipeline Systems
FCI 70-2	Control Valve Seat Leakage
ISA RP75.23	Considerations for Evaluating Control Valve Cavitation
ISA 75.01.01	Industrial-Process Control Valves – Part 2-1: Flow Capacity - Sizing Equations for Fluid Flow Under Installed Conditions
ISA 75.02	Control Valve Capacity Test Procedure
ISA 75.05	Control Valve Terminology
ISA 75.08.01	Face-to-Face Dimensions for Integral Flanged Globe-Style Control Valve Bodies (ANSI Classes 125, 150, 250, 300, and 600)
ISA 75.08.02	Face-to-Face Dimensions for Flangeless Control Valves (ANSI Classes 150, 300, 600)
ISA 75.08.06	Face-to-Face Dimensions for Flanged Globe-Style Control Valve Bodies (ANSI Classes 900, 1500, and 2500)
ISA 75.17	Control Valve Aerodynamic Noise Prediction

Document No.	Title
ISA 75.19.01	Hydrostatic Testing of Control Valves
ISA 75.25.01	Test Procedure for Control Valve Response Measurement from Step Inputs
Internal References – Documents Referenced by this Specification	
EDMS No. 3677475	TEF-MECH-LIQ-CV Liquid Control Valve Data Sheet Form (CDN-US-MEX)
EDMS No. 3677384	TEF-MECH-GAS-CV Gas Control Valve Data Sheet Form (CDN-US-MEX)
EDMS No. 8071725	TES-MATL-COMP Materials Requirements of Pressure Containing Equipment Components Specification (CDN-US-MEX)
EDMS No. 1001891682	TES-VALV- G Steel Valves for Gas Service Specification (CDN-US-MEX)
EDMS No. 1001895584	TES-VALV-L Steel Valves for Liquid Service Specification (CDN-US-MEX)
DS-4002 (CPG)	Pressure Regulation, Overpressure Protection & Flow Control Design
EDMS No. 3671710	TES-COAT-EPU Field-Applied External Liquid Coating Systems for Steel Pipes Specification (CDN-US-MEX)
EDMS No. 3694704	TES-COAT-P1 Paint Systems for Above Ground Facilities (Coastal and Non-Coastal) Specification (CDN-US-MEX)

11 DOCUMENT HISTORY

Rev.		
00	**Description**	**Effective Date**
	New document.	2016-Dec-01
	Rationale Statement	**Responsible Engineer**
	This document was developed / revised in order to address the following requirements: • Consolidation of specifications. The following specifications/documents have been combined into this document: – TES-MECH-CV-LIQ Control Valve Design Specification for Liquid Service (CDN-US-MEX) – TES-MECH-CV-GAS Control Valve Design Specification for Gas Service (CDN-US-MEX)	Dawood Habib
	Impact Assessment Summary	**Document Owner**
	Identify and address the potential impacts to operations, training, competency, safety and the environment, lines of business, based on the impact analysis done prior to the creation of the document.	Dawood Habib

12 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
N/A	This Specification is a new document.

13 APPROVALS

APPROVALS		
Originator: Masroor Husain, P. Eng. Design Services-FIDE	Signature	Nov 23, 2016 Date
Reviewer: Gerard Lalonde, P. Eng. Design Services-FIDE	Signature	Nov 23, 2016 Date
Reviewer: Vivian Liu, P. Eng. Design Services-FIDE	Signature	Nov 23, 2016 Date
Reviewer: Steven Foo, P. Eng. Measurements-Gas Project Engineering	Signature	Nov. 23, 2016 Date
Reviewer: Raymond Makar. TransCanada/CPG	Raymond Makar Signature	NOV 23, 2016 Date
Reviewer: Phil Gauthreaux Design Services-US	Signature	Nov. 23, 2016 Date
Reviewer: Dmitry Ryapolov CGO Tech Support	Signature	Nov 23, 2016. Date
Responsible Engineer: Dawood Habib, P. Eng. Design Services-FIDE	Signature NOV 24, 2016 Date	PROFESSIONAL ENGINEER DAWOOD HABIB SHEIKH ALBERTA APEGA Permit to Practice P7100. Rev 0
Management Endorsement: Muhammad Riaz, Manager Design Services- FIDE	Signature	Nov. 24th, 2016 Date

PURPOSE

This Standard defines requirements for the selection and design of filtration units for natural gas transmission systems and associated facilities.

SCOPE/APPLICABILITY

This Standard applies to slug catchers, harp type slug catchers, centrifugal/cyclonic separators, vane type separators, suction scrubbers, filter separators, coalescing filters and cone strainers.

This Standard does not apply to separation or filtration systems that are part of fuel gas systems except where the drain systems are connected.

This Standard applies to all divisions of the Company and its wholly-owned subsidiaries, and all operated entities/facilities in Canada, the United States (U.S.) and Mexico.

This Standard does not apply to liquids facilities except where natural gas utilities are present.

Within this Standard, TransCanada is referred to as the Company.

Within this Standard, the following terms and definitions apply for requirements:

- Shall—expresses a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard. Shall is not a recommendation but a requirement.
- Should—expresses a strong preference, recommendation or that which is advised, but not required.
- Must—denotes a requirement of the Company, for which no deviation or variance would be granted.
- May—expresses an option or that which is permissible within the limits of the standard.
- Consider—assumes that a competent person will evaluate options to fulfill the intent of the requirement and make a documented decision supported by evidence to ensure protection of people, equipment and the environment by achieving the appropriate level of functional integrity.

Wherein governmental or regulatory requirements conflict with this Standard, the more stringent requirement shall govern.

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1 GLOSSARY

Bridle

Also known as an instrument bottle. A small external vessel with top and bottom inlets mounted at the anticipated liquid level, allowing external mounting of level indicators, switches, etc.

Components

Any valves, flanges, flange accessories, standard fittings, taps, components fabricated by welding, welded branch connections, and extruded outlets.

dPIT

Differential Pressure Indicating Transmitter

ESD

Emergency Shutdown

Liquid accumulator barrel

Also known as a blowflask.

Piping

The inlet and outlet points of gas entry and fluid holding areas of the system.

2 GLOBAL CONSIDERATIONS AND DESIGN REQUIREMENTS

2.1 Global Considerations

2.1.1 Slug catchers, separators and filters are designed to remove particulates, liquids and mists from gas before it is processed through other operations (such as compression or measurement).

2.1.2 Slug catchers should be used to collect large volumes of liquids (slugs) that come through the pipeline.

2.1.3 Separators and filters should be used to catch lower concentrations of liquids as well as particulates and mists.

2.1.4 Filters or coalescing filters should be used where high separation efficiencies are required to protect downstream equipment.

2.1.5 The separation/filtration system should consist of the following components:

- separation/filtration device (slug catcher, separator, or filter as applicable)
- sump, which may be integral to the vessel
- drain system
- low pressure drain line cyclone separator, if required
- storage drain tank, with flame arrestor if required

2.1.6 Due to the wide variation in gas flow conditions and variation of characteristics of the equipment, the specifying engineer may need to select more than one piece of equipment to provide proper gas conditioning.

2.1.7 See the flow chart in Appendix A for further filtration selection guidance.

2.1.8 Designers shall consider the requirements in the following specifications, regulations and standards, as applicable:

- *TED-MATL-FRAC Materials Fracture Control Plan (CAN-US-MEX)* (EDMS No. 007076183)
- Canada: CSA Z662 *Oil and Gas Pipeline Systems*
- U.S.: 49 CFR 192 *Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards*
- Mexico: NOM-007-SECRE-2010 *Transporte de gas natural*

2.2 Global Considerations for Compressor Stations

2.2.1 Each compressor unit shall be protected against the introduction of liquids, entrained vapors and other contaminants in quantities.

2.2.2 A natural gas separation or filtration system should be installed in the high-pressure gas piping downstream of the station suction isolation valve (ESD valve). Where mainline filtration is desired during station by-pass operation, consider installing the system upstream of the station suction isolation valve (ESD valve).

2.2.3 If appropriately sized, a single system may be used for the protection of multiple compressor units.

2.2.4 For stations operating centrifugal compressors, the system shall be capable of removing 99.8% of all particles and liquids 10 microns and larger over the expected range of gas flows.

2.2.5 For stations operating reciprocating compressors, the system shall be capable of removing 99.8% of all particles and liquids 1 micron and larger over the expected range of gas flows.

2.2.6 The low pressure drain line cyclone separator, if required, shall provide separation of the collected liquids and other contaminants from any entrained natural gas, allowing mist-free natural gas to dissipate and the liquids and other contaminants to gravity drain into the drain tank.

2.3 Global Considerations for Measurement and Regulating Stations

2.3.1 Measurement equipment should be protected against the introduction of liquids, entrained vapors and other contaminants in quantities that could cause equipment damage or measurement error.

2.3.2 If appropriately sized, a single system may be used for the protection of multiple meter runs.

2.3.3 For measurement and regulating stations, the system shall be capable of removing 99.8% of all particles and liquids over the expected range of gas flows as follows:

- Canada and Mexico: 10 microns and larger
- U.S.: 3 microns and larger

2.4 Global Considerations for Mainline Separation or Filtration

2.4.1 Where specified, launcher/receiver sites or mainline piping may be equipped with a natural gas separation or filtration system to extract liquids, entrained vapors and other contaminants in quantities that could cause damage. If installed at launcher/receiver sites, the system should be on the kicker line.

2.4.2 For launcher/receiver sites or mainline filtration sites, the filtration system shall be capable of removing 99.8% of all particles and liquids 10 microns and larger over the expected range of gas flows.

2.5 Global Design Requirements

2.5.1 The equipment shall be designed to this Standard, and site-specific and operating requirements.

2.5.2 The separation or filtration system pressure vessels shall be manufactured as specified in *TES-ME-PV1-GLE Pressure Vessels Specification (CAN-US-MEX)* (EDMS No. 000006406).

2.5.3 The bridles (instrument bottles) shall be fabricated by the separation/filtration device manufacturer.

2.5.4 The system pressure vessels shall be designed to a maximum allowable working pressure equal to or greater than the facility design pressure or pipeline design pressure as applicable. Typically, this will be 10% greater than the design pressure to account for pressure-relieving devices.

2.5.5 Vessels shall have supports, anchors or attachment points designed for any reaction forces due to process conditions, and wind or snow loading and/or earthquake zone conditions.

2.5.6 The system shall be provided with overpressure protection by a relieving device or with overpressure protection by system design.

2.5.7 A fire-sized relief valve shall be considered if pressure vessels could be isolated from the system's overpressure relieving device or overpressure protection system.

2.5.8 The system shall be designed to a minimum design metal temperature (MDMT) of -45°C (-50°F) or -29°C (-20°F) in accordance with *TED-MATL-FRAC Materials Fracture Control Plan (CAN-US-MEX)* (EDMS No. 007076183), and a maximum temperature of 75°C (167°F) unless a higher design temperature is required due to process conditions.

2.5.9 Separation systems shall be specified to have a maximum pressure drop of 14 kPad (2.0 psid) at maximum design flow and minimum pressure.

2.5.10 Filtration systems shall have a maximum design pressure drop at rated capacity in new condition of 14.0 kPad (2.0 psid) and shall alarm at 70 kPad (10 psid) with shutdown at 95 kPad (14 psid) or as recommended by the Vendor.

2.5.11 If no drain system and sump are installed, the pressure vessel shall be equipped with a grounding lug or static bonding and grounding reel.

2.6 Sump Requirements

2.6.1 There shall be an appropriate area or volume for catching and retaining the liquids and other contaminants.

2.6.2 Liquid storage shall be designed to have sufficient retention time before dumping to allow entrained gas to dissipate from the liquid.

2.7 Drain System Requirements

2.7.1 There shall be a method of removing the liquids and other contaminants from the equipment.

2.7.2 At compressor stations, automatic liquid dumps are required unless otherwise specified by the Company and shall be designed to remove at least two times the rate of any anticipated rate of liquid or material influx.

2.7.3 At meter stations and launcher/receiver sites, either manual or automatic dumps should be installed as specified by the Company.

2.8 Instrumentation Requirements

2.8.1 Adequate instrumentation shall be installed to permit safe monitoring, operation and control of the separation/filtration system.

2.9 Insulation or Freeze Protection Requirements

2.9.1 Where insulation is required, sump areas of the vessel shall be heated and/or insulated in accordance with *TES-ME-INSUL-GLE Piping and Equipment Insulation Specification (CAN-US-MEX)* (EDMS No. 1003873027).

2.9.2 Condition monitoring location (CML) ports on the shell, heads and boots shall be considered for inspection in accordance with *TES-ME-INSUL-GLE Piping and Equipment Insulation Specification (CAN-US-MEX)* (EDMS No. 1003873027).

2.9.3 Internal piping/tubing coil for anti-freeze circulation in the liquid collection area may also be considered.

2.9.4 A fabricated sump enclosure that contains catalytic heaters may also be considered.

2.9.5 If a fabricated sump enclosure is used, the enclosure shall be designed to allow access for maintenance and inspection. See Figure 2-1 and Figure 2-2 for interior and exterior photos of a typical installation.

Figure 2-1: Enclosure Interior Detail

Figure 2-2: Enclosure Exterior

3 SLUG CATCHER

3.1 Slug Catcher General Requirements

3.1.1 The vessel shall be designed for shock loading due to the arrival of liquid slugs.

3.1.2 Any internals shall be designed to resist damage due to liquid slugs.

3.1.3 The slug catcher shall meet the following efficiencies:

- 100% of free liquids including slugs
- 99.0% of droplets 10 microns and larger

3.1.4 Consider a mist eliminator near the outlet portion of the vessel to capture fine liquids carried by the gas flow. If required, specify on the datasheet.

3.2 Harp Type Slug Catcher Design Requirements

3.2.1 The reaction forces generated by inlet flow rate and velocity shall be listed on the datasheet.

3.2.2 Harp type slug catcher assemblies shall include the following major equipment components (see Figure 3-1):

- storage "harps"
- dry gas risers
- dry gas outlet
- separation chambers

- liquid and storage manifold
- distribution manifold
- two-phase (wet) gas inlet
- vent gas piping with supports
- structural storage tube anchors
- structural sliding supports

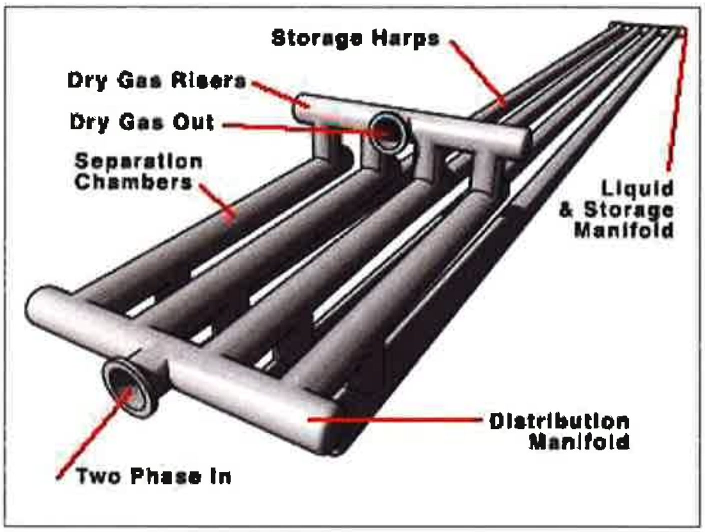


Figure 3-1: Harp Type Slug Catcher

3.3 Horizontal Vessel Type Slug Catcher Requirements

3.3.1 Consider a bottom sump. If required, specify on the datasheet.

3.3.2 If bottom sumps are specified, they shall include full opening blind flanges on each end to facilitate inspection and cleaning.

3.3.3 The quantity of expected free liquids shall be stated on the datasheet.

Note:

Figure 3-2 shows a typical horizontal vessel type slug catcher.

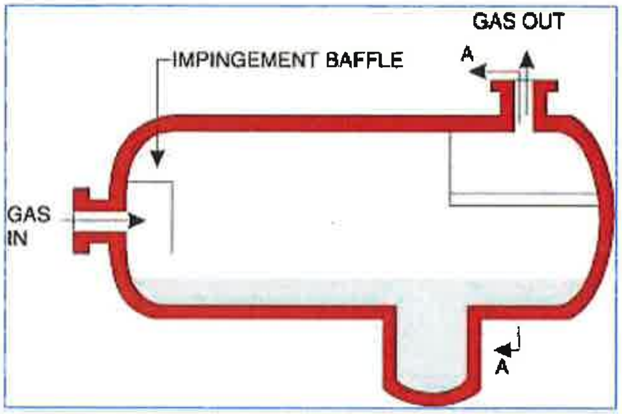


Figure 3-2: Horizontal Vessel Type Slug Catcher

3.4 Vertical Vessel Type Slug Catcher Requirements

3.4.1 Vertical slug catchers shall have a minimum sump capacity of 3,800 L (1,000 gal.) and the ability to handle a 1,900 L (500 gal.) slug, unless the designer notes otherwise on the datasheet.

3.5 Dump System Requirements

3.5.1 A manual dump system shall be installed for each section of the slug catcher.

3.5.2 Consider an automatic dump system in parallel with a manual dump system.

3.6 Instrumentation Requirements

3.6.1 As applicable, the instrumentation should generally follow the arrangement shown in Appendix B.

3.6.2 Level gauges and level switches shall be installed on each section of the slug catcher.

3.6.3 For horizontal vessels with sumps, a bridle (instrument bottle) shall be installed on each sump to permit the installation of devices for remote monitoring and controlling the liquid level in the sump.

3.6.4 The scope of work and datasheet shall specify that the Vendor shall provide, at a minimum, the connections and provisions for the following equipment and instrumentation:

- liquid-filled pressure gauge with isolation valve
- temperature gauge
- relief valve connection, if specified
- dump valve connection with siphon off the side
- bottom drain connection

- adequate venting for purging the system
- upper and lower level gauge/switch connections with level gauge or switches for each vessel section
- level gauges, if specified, shall be supplied with valves to permit isolation and cleaning while vessel is in-service

4 SEPARATION SYSTEMS

4.1 Horizontal Suction Separator/Scrubber Design Requirements

4.1.1 The separator/scrubber elevation from scrubber centreline to bottom of support steel should be adequate to ensure the scrubber sumps, instrumentation and drainage systems can be installed below the scrubber shell.

4.1.2 Separators/scrubbers and bridles (instrument bottles) shall follow the arrangements shown on *STDS-01-CS-03-088 Typ. Scrubber Arrangement Centrifugal Station* and *STDS-01-CS-03-090 Suction Scrubber Instrument Bottles* as applicable.

4.2 Suction Separator/Scrubber Sump Design Requirements

4.2.1 Vertical sumps should be provided directly below the horizontal separator/scrubber barrel to collect and hold the liquids and solids knocked out of the gas for periodic disposal.

4.2.2 Two sumps, minimum NPS 16, are preferred. Each vertical sump should have an active liquid holding capacity of 40 L (10 gal.) as minimum.

4.2.3 At stations with a history of high liquid levels, consider increasing the sump size or including a larger horizontal liquid accumulator barrel, as shown in Figure 5-1.

4.2.4 Two NPS 2 connections shall be provided on each of the vertical sumps; one for the top bridle connection, the second for the combined bottom bridle, auto-dump and manual dump connection, as shown on the left side of Figure 4-1; except in cases where the alternate arrangement described in 4.2.5 is used.

4.2.5 Where high concentrations of solids are expected, a separate lower connection for the bridle and auto-dump with a siphon and a bottom connection for the manual dump connection may be utilized, as shown on the right side of Figure 4-1.

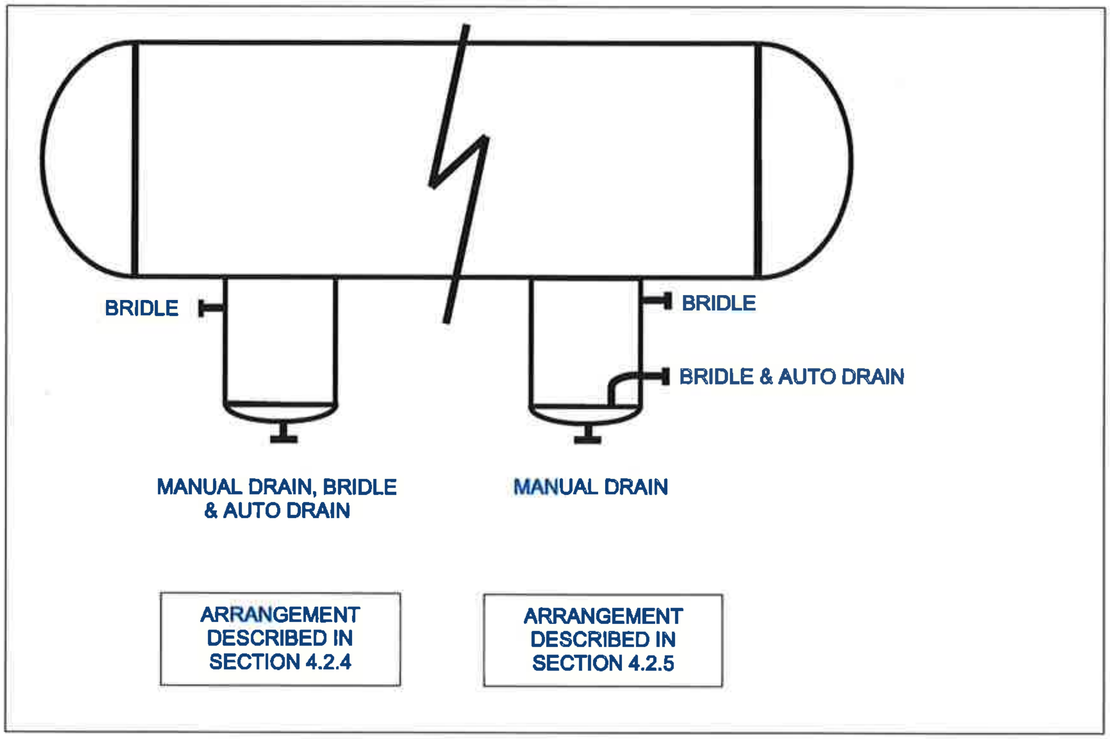


Figure 4-1: Sump Design Requirements

4.2.6 One NPS 6 port shall be provided on each of the vertical sumps to provide an inspection or cleanout access.

4.3 Centrifugal/Cyclonic Separator Design Requirements

4.3.1 Centrifugal/cyclonic separator assemblies (see Figure 4-2), shall include the following major equipment components:

- separator pressure vessel
- mist pad or vane assembly
- provisions for inducing gas swirl
- access manway and inspection ports for inspection and cleaning
- dump system

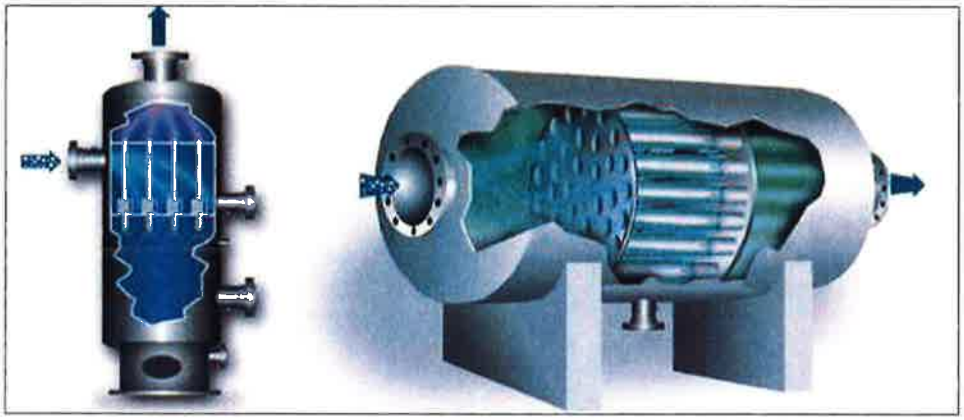


Figure 4-2: Centrifugal/ Cyclonic/ Type Gas Cleaner Pressure Vessel

4.3.2 To improve the performance of the system, the following deviations may be used:

- mechanism for inducing swirl (inlet baffle, cyclone tubes, etc.)
- mist pad, vane assembly or other means of trapping small liquid particles
- modification of the sump size/typical retention time

4.4 Vane Type Separator Design Requirements

4.4.1 Vane type separator assemblies shall include the following major equipment components:

- separator pressure vessel
- mist pad and vane assembly
- access manway and inspection ports for inspection and cleaning
- dump system

4.4.2 To improve the performance of the system, the following deviations may be included:

- mist pad or other means of trapping small liquid particles
- modification of the sump size/typical retention time
- method and actuation of level control

5 FILTRATION

5.1 Filter-Separator General Considerations

5.1.1 Filter-separators (see Figure 5-1) shall be designed to remove entrained liquid and solid particles, including dust, rust, compressor oils, liquid hydrocarbons, glycol and water from the natural gas stream.

5.1.2 There shall be adequate clearance below the filter-separator shell to install the sumps, instrumentation and drainage system.

5.1.3 Filter-separators shall be furnished complete with a horizontal liquid accumulator barrel and liquid dump systems serving both ends of the filter-separator/accumulator.

5.1.4 The accumulator shall have 150 L (40 gal.) minimum capacity and quick-opening (i.e., non-threaded) closures on both ends.

5.1.5 Filter-separators and bridles shall follow the arrangements shown on *STDS-01-CS-03-089 Typ. Scrubber Arrangement Reciprocating Station* and *STDS-01-CS-03-090 Suction Scrubber Instrument Bottles* as applicable.

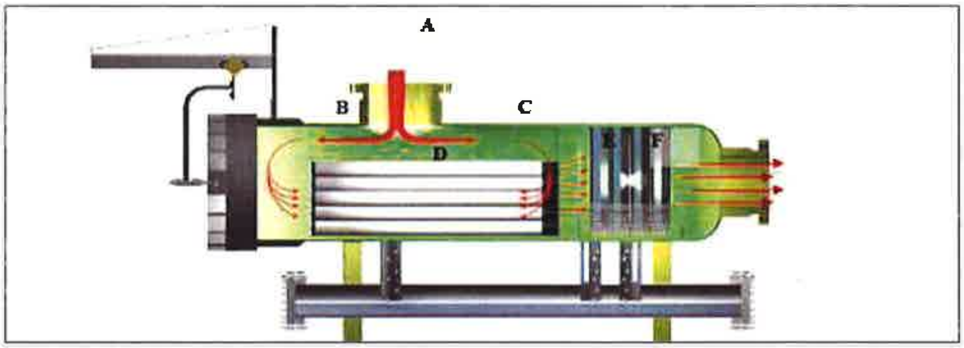


Figure 5-1: Filter-Separator Schematic

5.2 Filter-Separator Design Requirements

5.2.1 The vessel shall be capable of handling flows from zero to full design capacity with no reduction in efficiencies at the lower flows.

5.2.2 The design for horizontal and vertical type filters shall incorporate a “full end” end closure (i.e., the end closure shall match the vessel diameter), designed for optimal safety and ease of access for routine maintenance (cleaning and filter element replacements). Quick opening closures (i.e., non-threaded) are preferred.

5.2.3 The enclosures shall be meet *TES-FITG-EC1 End Closures Specification* (EDMS No. 003779256).

5.2.4 Mist extractors shall be of stainless steel construction.

5.2.5 If a mist extractor is specified, an inspection opening shall be provided to allow visual inspection and cleaning of the mist extractor.

5.2.6 Two connections shall be provided, one at each end of cyclone tube type separators, to be used to flush the interior.

5.3 Coalescing Filter-Separator Design Requirements

5.3.1 Unless otherwise specified, coalescing filter separators should be of the forward flow type.

5.3.2 Coalescing filter-separators (see Figure 5-2) shall include the following major equipment components:

- separator pressure vessel
- filter elements
- filter element supports
- filter access with access door supported either by hinges or a davit assembly (for vertical vessels, clam shell type vessels are preferred)
- separate sump and dump controls for the filter section and for separator sections, if separator section is specified
- mist eliminator

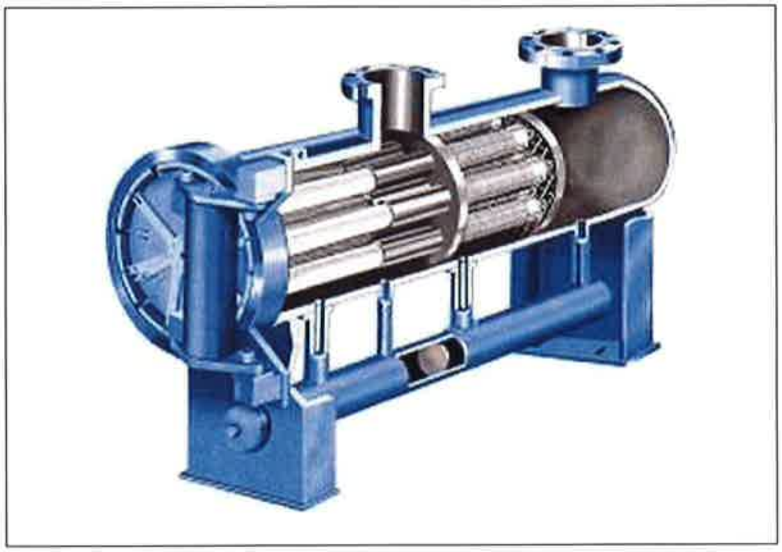


Figure 5-2: Coalescing Filter-Separator Pressure Vessel

6 INSTRUMENTATION AND DUMP DESIGN REQUIREMENTS FOR VESSELS WITH VERTICAL SUMPS

6.1 Design Requirements for Compressor Stations

6.1.1 Instrumentation should generally follow the arrangement shown in Appendix D.

6.1.2 The differential pressure across the filtration system shall be measured using a differential pressure gauge.

6.1.3 A differential pressure transmitter should be installed to alarm and/or shut down the downstream equipment when predetermined values are reached.

6.1.4 Where a differential pressure transmitter is installed, consider using a combined differential pressure transmitter (dPIT).

6.1.5 The scope of work and datasheet shall specify that the Vendor shall provide, at a minimum, the connections and provisions for the following equipment and instrumentation:

- differential pressure gauge with integral five-way manifold valve
- differential pressure transmitter, if specified
- liquid filled pressure gauge with isolation valve
- temperature gauge
- relief valve connection
- automatic dump valves, if specified
- manual dump valves
- adequate venting for purging the system
- liquid level control bridles (instrument bottles) to include:
  - top vent connection
  - bottom drain plug
  - three level gauge connections
  - liquid reservoir low level alarm switches
  - liquid reservoir high-level alarm switches
  - liquid reservoir high-high level alarm switches

Note:

Where external power is not available, consider replacing level switches with liquid level controllers with externally caged floats.

6.1.6 NPS 2 ball valves shall be installed between the scrubber sump and bridles connections for isolation purposes.

6.1.7 NPS 1 ball valves shall be installed in the vent and drain connections of each bridle.

6.1.8 Bridles shall be fabricated by the separator/scrubber manufacturer.

6.2 Design Requirements for Measurement and Regulating Stations

6.2.1 The scope of work and datasheet shall specify that the Vendor shall provide, at a minimum, the connections and provisions for the following equipment and instrumentation:

- differential pressure gauge with integral 5-way manifold valve
- differential pressure transmitter, when required

- instrument that provides visual verification of liquid level, such as a sight-glass, with valves to provide the capability to isolate and clean the instrument
- high point vent
- port for high level switch

6.2.2 Consider measuring the differential pressure across the filtration system using a differential pressure gauge and transmitter.

6.2.3 Consider a differential pressure transmitter to alarm and/or shut down the downstream equipment when predetermined values are reached.

6.2.4 Where a differential pressure transmitter is installed, consider using a combined differential pressure transmitter (dPIT).

6.3 Manual Dump Line Design Requirements

6.3.1 Two NPS 2 ball valves shall be installed between each separator/scrubber sump and manual dump line.

6.3.2 The ball valve immediately downstream of the sump shall be normally opened and the other ball valve shall be normally closed.

6.3.3 An NPS 2 line shall take off from each set of manual dump valves and join to form a common drain line header.

6.3.4 An NPS 1 line shall take off from each bridle and join the common drain header.

6.3.5 The common drain header shall be sloped at a minimum of 1% toward the storage drain tank (or cyclone separator if installed).

6.3.6 The drain line shall be designed to the same design pressure as upstream pressure equipment.

6.4 Automatic Dump Line Design Requirements

6.4.1 The automatic dump line shall be connected immediately downstream of the normally opened NPS 2 ball valve described in 6.3.1.

6.4.2 An automatic dump valve shall be installed in the automatic dump line downstream of each NPS 2 ball valve in parallel with the manual dump valve.

6.4.3 The automatic dump valves shall be specified to fail closed on loss of control signal or ESD condition.

6.4.4 A restriction orifice should be installed in the vertical section of the automatic dump piping immediately downstream of each automatic dump downstream isolation valve to provide pressure reduction downstream of the control valve to prevent freeze off and/or excessive seat wear.

6.4.5 The automatic and manual dump lines shall be connected together in the vicinity of the suction scrubber, and the common drain header shall be sloped at a minimum of 1% toward the storage drain tank (or cyclone separator) if installed.

7 INSTRUMENTATION AND DUMP DESIGN REQUIREMENTS FOR VESSELS WITH A HORIZONTAL LIQUID ACCUMULATOR BARREL

7.1 Design Requirements for Compressor Stations

7.1.1 Instrumentation should generally follow the arrangement shown in Appendix C.

7.1.2 The differential pressure across the filtration system shall be measured using a differential pressure gauge.

7.1.3 A differential pressure transmitter should be installed to alarm and/or shut down the downstream equipment when predetermined values are reached.

7.1.4 Where a differential pressure transmitter is installed, consider using a combined differential pressure transmitter (dPIT).

7.1.5 The scope of work and datasheet shall specify that the Vendor shall provide, at a minimum, the connections and provisions for the following equipment and instrumentation:

- differential pressure gauge with integral five-way manifold valve
- differential pressure transmitter, if specified
- liquid filled pressure gauge with isolation valve
- temperature gauge
- relief valve connection
- automatic dump valves, if specified
- manual dump valves
- adequate venting for purging the system
- liquid level control bridles (instrument bottles) to include:
    - top vent connection
    - bottom drain plug
    - three level gauge connections
    - liquid reservoir low level alarm switches
    - liquid reservoir high-level alarm switches
    - liquid reservoir high-high level alarm switches

Note:

Where external power is not available, consider replacing level switches with liquid level controllers with externally caged floats.

7.1.6 NPS 2 ball valves shall be installed between the liquid accumulator barrel and bridle connections for isolation purposes.

7.1.7 NPS 1 ball valves shall be installed in the vent and drain connections of each bridle.

7.2 Design Requirements for Measurement and Regulating Stations

7.2.1 The scope of work and datasheet shall specify that the Vendor shall provide, at a minimum, the connections and provisions for the following equipment and instrumentation:

- differential pressure gauge with integral five-way manifold valve
- differential pressure transmitter, if specified
- instrument that provides visual verification of liquid level, such as sight-glass, with valves to provide the capability to isolate and clean the instrument
- high point vent
- port for high level switch

7.2.2 Consider measuring the differential pressure across the filtration system using a differential pressure gauge.

7.2.3 A differential pressure transmitter should be installed to alarm and/or shut down the downstream equipment when predetermined values are reached.

7.2.4 Where a differential pressure transmitter is installed, consider using a combined dPIT.

7.3 Manual Dump Line Design Requirements

7.3.1 An NPS 2 ball valve shall be installed between each side of the liquid accumulator barrel and the manual dump line.

7.3.2 The ball valve shall be normally closed.

7.3.3 An NPS 2 line shall take off from each set of manual dump valves. Each line shall join an automatic dump line then pass through a check valve and restriction orifice before combining to form a single line to the storage dump tank.

7.3.4 The drain line shall be designed to the same design pressure of upstream pressure equipment.

7.4 Automatic Dump Line Design Requirements

7.4.1 An automatic dump valve shall be connected between two normally open NPS 2 ball valves on each side of the liquid accumulator barrel.

7.4.2 The automatic dump valves shall be specified to fail closed on loss of control signal or in an ESD condition.

7.4.3 Each NPS 2 automatic dump line shall join the manual dump line for each side of the liquid accumulator barrel.

7.4.4 The dump lines from each side of the liquid accumulator barrel shall be connected together in the vicinity of the suction scrubber and this common drain head shall be routed to the storage drain tank (or cyclone separator if installed), at a 1% slope.

8 INSTRUMENTATION AND DUMP DESIGN REQUIREMENTS FOR VERTICAL VESSELS

8.1 Design Requirements for Compressor Stations

8.1.1 Instrumentation should generally follow the arrangement shown in Appendix B.

8.1.2 The differential pressure across the filtration system shall be measured using a differential pressure gauge.

8.1.3 A differential pressure transmitter should be installed to alarm and/or shut down the downstream equipment when predetermined values are reached.

8.1.4 Where a differential pressure transmitter is installed, consider using a combined differential pressure transmitter (dPIT).

8.1.5 The scope of work and datasheet shall specify that the Vendor shall provide, at a minimum, the connections and provisions for the following equipment and instrumentation:

- differential pressure gauge with integral five-way manifold valve
- differential pressure transmitter, if specified
- liquid filled pressure gauge with isolation valve
- temperature gauge
- relief valve connection
- automatic dump valves, if specified
- manual dump valves
- top vent connection
- bottom drain plug
- three level gauge connections
- liquid reservoir low level alarm switches
- liquid reservoir high-level alarm switches
- liquid reservoir high-high level alarm switches

Note:

Where external power is not available, consider replacing level switches with liquid level controllers with externally caged floats.

8.2 Design Requirements for Measurement and Regulating Stations

8.2.1 Instrumentation should generally follow the arrangement shown in Appendix E.

8.2.2 The scope of work and datasheet shall specify that the Vendor shall provide, at a minimum, the connections and provisions for the following equipment and instrumentation:

- differential pressure gauge with integral five-way manifold valve
- differential pressure transmitter, if specified
- instrument that provides visual verification of liquid level, such as sight-glass, with valves to provide the capability to isolate and clean the instrument
- high point vent
- port for high level switch

8.2.3 Consider measuring the differential pressure across the filtration system using a differential pressure gauge.

8.2.4 A differential pressure transmitter should be installed to alarm and/or shut down the downstream equipment when predetermined values are reached.

8.2.5 Where a differential pressure transmitter is installed, consider using a combined differential pressure transmitter.

8.3 Manual Dump Line Design Requirements

8.3.1 An NPS 2 ball valve shall be installed between each section of the vessel and the manual dump line.

8.3.2 The ball valve shall be normally closed.

8.3.3 An NPS 2 line shall take off from each manual dump valve and shall connect together in the vicinity of the vessel; this common drain header shall be routed to the storage drain tank.

8.3.4 The drain line shall be designed to the same design pressure as upstream pressure equipment.

8.4 Automatic Dump Line Design Requirements

Note:

The clauses in this section apply only if an automatic dump valve is specified.

8.4.1 The automatic dump valve shall be connected in parallel with the manual dump valve between two normally open NPS 2 ball valves.

8.4.2 The automatic dump valve shall be specified to fail closed on loss of control signal or in an ESD condition.

8.4.3 The dump lines from each section of the vessel shall be connected together in the vicinity of the vessel, and this common drain head shall be routed to the storage drain tank (or cyclone separator if installed), at a 1% slope.

9 LOW PRESSURE DRAIN LINE CYCLONE SEPARATOR

9.1 General Requirements

9.1.1 Consider a cyclone separator to separate liquid and gas in the compressor station scrubber drain and fuel gas drain system.

9.1.2 Where low volumes of liquids and other contaminants are expected, the cyclone separator may be omitted.

9.1.3 If the cyclone separator is omitted from the design, the drain line and drain tank design shall ensure there is no risk of over-pressuring the drain tank during automatic or manual dumping, and that mist carryover from the drain tank during automatic or manual dumping is minimized.

9.2 Design Requirements

9.2.1 A vertical cyclone separator should normally be selected for gas/liquid separation.

9.2.2 The cyclone separator shall have a design pressure of 103 kPa (15 psig), with blowdown vents to atmosphere.

9.2.3 The cyclone separator liquid drain shall be located at the bottom of the separator. An NPS 4 (preferred size) pipe shall be connected between the liquid drain and the drain tank.

9.2.4 The line between the cyclone separator and drain tank shall be sloped a minimum 1% grade towards the drain tank, to ensure gravity drainage of liquids to the drain tank.

9.2.5 Detailed design of the cyclone separator shall be in accordance with *STDS-01-CS-03-091 Typical Scrubber Arrangement – Centrifugal Station*.

10 GAS PROCESS STORAGE DRAIN TANK

10.1 Storage Drain Tank General Requirements

10.1.1 A double-walled steel tank shall be installed in the compressor/meter station yard in the vicinity of the cyclone separator to provide temporary storage of liquid waste drained from the filtration system and fuel gas drain.

10.1.2 The storage drain tank shall be fabricated in accordance with *TES-MECH-ASFT Aboveground Shop Fabricated Tanks Specification (CAN-US-MEX)* (EDMS No. 009214522).

10.1.3 Above ground field-erected tanks shall be in accordance with *TES-ME-AST-GLE Field-Erected Aboveground Storage Tanks Atmospheric Specification* (CAN-US-MEX) (EDMS No. 008042207).

10.1.4 Underground tanks, if applicable, shall be in accordance with *TES-ME-UST-GLE Underground Tank Specification (CAN-US-MEX)* (EDMS No. 008113769).

10.1.5 If required by local codes or regulations, or the result of a Process Hazard Assessment, a flame arrestor shall be installed on the drain tank vent.

10.1.6 If the storage drain tank vent height is mandated by local codes or regulations, ensure the height meets minimum requirements based on tank volume, liquid type and class.

10.1.7 Consider adding a static bonding and grounding reel to the storage drain tank in lieu of a grounding lug.

10.2 Storage Drain Tank Design Requirements

10.2.1 The storage drain tank capacity should not be less than 5,000 L (1,320 gal.).

10.2.2 The storage drain tank shall be equipped with a high-level alarm to alert operators to dispose of tank contents as soon as possible.

10.2.3 Sufficient volume above the high-level alarm should be provided for collecting solids and liquids from the suction scrubber.

10.2.4 The storage drain tank shall be equipped with a high-high level station shutdown lockout to eliminate the possibility of liquids overfilling the drain tank and to ensure that liquids collected in the scrubber sumps are not vented to atmosphere through the cyclone separator.

10.2.5 For facilities with multiple storage drain tanks, the high-high level alarm shall shut off the drain to the associated drain tank, allowing the facility to continue to operate until all tanks reach high-high level.

10.2.6 If required due to regular freezing conditions at the facility site, the drain tank should be insulated and heated, and the enclosure should include temperature instruments and a pump out connection.

10.2.7 The storage drain tank should be prefabricated, skid mounted, and shipped to the site as a complete system.

11 CONE STRAINER

11.1 Cone Strainer General Considerations

11.1.1 The units (see Figure 11-1) shall be installed at locations in process systems where particulate matter may adversely affect the operation of equipment or systems.

11.2 Cone Strainer Design Requirements

11.2.1 Strainers may be provided in diameter and bolt-hole patterns to match ANSI classes 150, 300, 600, 900, 1500 or 2500, as indicated by the service location.

11.2.2 The certifying engineer shall develop a project-specific datasheet, specifying the intended service for cone installation (e.g., pipe diameter and ANSI flange class).

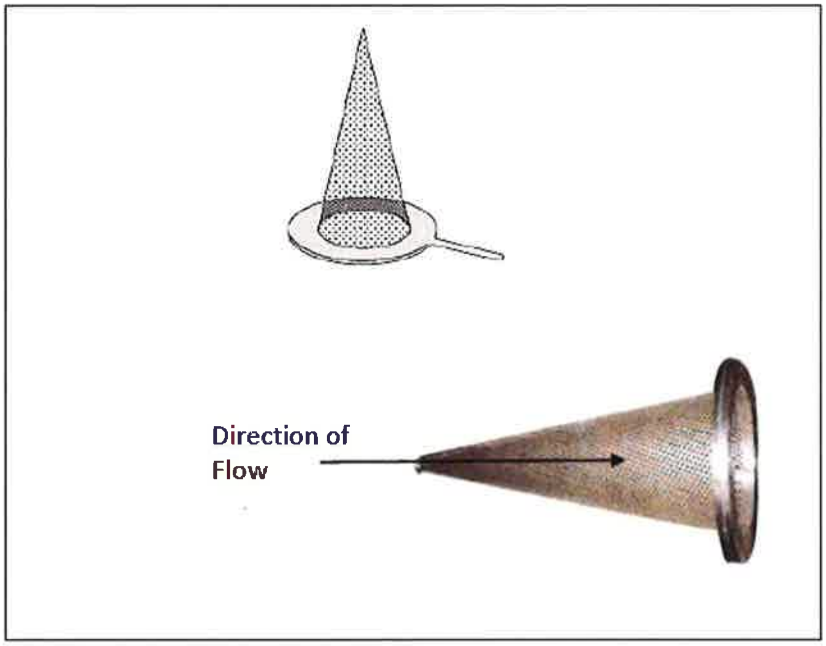


Figure 11-1: In-Line (Cone Type) Strainers

11.2.3 The strainer (without the fabric) shall have a minimum of 200% flow area with 3 mm (1/8 in.) holes at 13 mm (3/16 in.) spacing and shall have not less than 100% flow area with the wire mesh installed.

11.2.4 Wire fabric shall be on the upstream side of the cone and of square mesh construction having a maximum 30-mesh opening.

11.2.5 To improve the performance of the system, one or more of the following deviations may be used:

- reduced diameter to fit inside an ANSI flange bolt circle; however, this deviation is not permitted where flat-faced flanges are used
- support structure for the perforated cone

11.2.6 For start-up cone strainers, a matching spacer ring shall be provided by the Vendor, allowing removal of the cone strainer without impacting the piping or equipment alignment.

12 VENDOR CONSIDERATIONS

12.1 Technical Proposal Information Requirements

The designer shall ensure the request for proposal includes the Vendor requirements in this section.

12.1.1 The Vendor shall provide the following information:

- slug, solid and droplet removal capabilities
- capacity curves (pressure versus flow rate), and actual pressure drop (clean & dry and clean & wet for filter-separators) at design condition
- guaranteed removal efficiency based on total vessel configuration, including vessel internal separation device and filter elements if included
- sump capacity to meet or exceed the capacity specified on the datasheet
- the maximum (clean & dry and clean & wet) operating pressure drops across tube sheet or any gas deflection device internally placed in the vessel
- separate pricing for accessories, itemizing the description and prices for relief valve, bridle (instrument bottle) assembly, level control valves, level alarms, differential pressure transmitter and manual drain/vent valves
- outline drawing of proposed equipment noting the size, weight, support locations, nozzles and equipment layout

12.1.2 The system, including foundation mountings, shall be designed to absorb and transmit to the foundation the reaction forces generated by the inlet flow rate and velocity specified in the datasheet.

12.1.3 Inlet nozzles shall be designed, oriented, or shall have internal baffling so that inlet gas flow does not directly impinge on any internal surface of the vessel.

12.1.4 Vessel sizing and sump sizing shall take into account the amount of gas flow required and the expected quantity of free liquid slugs.

12.1.5 The base of the vessel shall be designed and constructed to support the weight of the vessel and the maximum amount of liquids.

12.1.6 The base of vertical vessels shall have an opening for pipe and vessel inspection purposes, which shall have an area equivalent to a 508 mm (20 in.) diameter opening.

12.2 Additional Filter-Separator Technical Proposal Information Requirements

The designer shall ensure the request for proposal includes the following Vendor requirements:

- number, type and cost of filter elements to meet rated efficiency
- the filter's rated collapse pressure
- the cost of full-size flanges with davits or hinges as an alternative

13 VARIANCES

Any deviation shall follow the Company's *Controlled Document Variance Procedure (Cdn-US-Mex)* (EDMS No. 007728702). External Vendors shall contact the Company Project Engineer or another authorized Company representative for variance approval.

14 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are listed in Table 14-1, Table 14-2 and Table 14-3. Use the latest document revision, unless otherwise approved by TransCanada.

Table 14-1: Regulatory References

Organization/Document No.	Title
Canadian Standards Association (CSA)	CSA Z662 *Oil and Gas Pipeline Systems*
Code of Federal Regulations (CFR)	49 CFR 192 *Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards*
Norma Oficial Mexicana (NOM)	NOM-007-SECRE-2010 *Transporte de gas natural*

Table 14-2: External Industry References

Organization/Document No.	Title
For this Specification, there are no specific external industry references.	

Table 14-3: Internal References

Document No.	Title
EDMS No. 007728702	*Controlled Document Variance Procedure (Cdn-US-Mex)*
EDMS No. N/A	STDS-01-CS-03-088 *Typ. Scrubber Arrangement Centrifugal Station*
EDMS No. N/A	STDS-01-CS-03-089 *Typ. Scrubber Arrangement Reciprocating Station*
EDMS No. N/A	STDS-01-CS-03-090 *Suction Scrubber Instrument Bottles*
EDMS No. N/A	STDS-01-CS-03-091*Cyclone Separator Details*
EMDS No. 007076183	*TED-MATL-FRAC Materials Fracture Control Plan (CAN-US-MEX)*
EDMS No. 003677428	*TEF-ME-FIL-GE Separator and Filter Data Sheet*

Document No.	Title
EDMS No. 003779256	*TES-FITG-EC1 End Closures Specification (CDN-US-MEX)*
EDMS No. 008042207	*TES-ME-AST-GLE Field-Erected Aboveground Storage Tanks Atmospheric Specification (CAN-US-MEX)*
EDMS No. 009214522	*TES-MECH-ASFT Aboveground Shop Fabricated Tanks Specification (CAN-US-MEX)*
EDMS No. 1003873027	*TES-ME-INSUL-GLE Piping and Equipment Insulation Specification (CAN-US-MEX)*
EDMS No. 000006406	*TES-ME-PV1-GLE Pressure Vessels Specification (CAN-US-MEX)*
EDMS No. 008113769	*TES-ME-UST-GLE Underground Tank Specification (CAN-US-MEX)*

15 DOCUMENTATION AND RECORDKEEPING

Designers shall ensure that all technical document submittal requirements are provided in the Vendor Technical Document Requirements List (VDRL) included with the proposal request or purchase order.

16 DOCUMENT HISTORY

<table>
<tr><th>Rev.</th><th></th><th></th></tr>
<tr><td rowspan="7">00</td><td>Description</td><td>Effective Date</td></tr>
<tr><td>New document.</td><td>2018-Jan-01</td></tr>
<tr><td>Rationale Statement</td><td>Responsible Engineer</td></tr>
<tr><td>This document was developed in order to address the following requirements:
• Consolidation of the following specifications/documents:
▪ Coalescer Filter Specification Material/Equipment Spec. No.: EQ.40.004 - CPG
▪ Cone Strainer Specification Material/Equipment Spec. No.: EQ.40.006
▪ Cyclonic Separator Specification Material/Equipment Spec. No.: EQ.40.003
▪ Filter Separator Specification Material/Equipment Spec. No.: EQ.40.008
▪ Gas Cleaner and Slug Catcher Standard DESIGN STANDARD NO.: DS.40.003
▪ Harp Separator Specification Material/Equipment Spec. No.: EQ.40.002
▪ Slug Catcher Specification Material/Equipment Spec. No.: EQ.40.015
▪ Vane Separator Specification Material/Equipment Spec. No.: EQ.40.005
▪ TES-Gas Scrubber Separator Specification EDMS No. 9092437
▪ TEN-ME-HPG-G Compressor Station High Pressure Gas Piping Design (sections of this Specification)</td><td>Greg Szuch, P. Eng.</td></tr>
<tr><td>Impact Assessment Summary</td><td>Document Owner</td></tr>
<tr><td>This Standard is an amalgamation of existing requirements. There is no impact to operations, training, competency, safety or the environment. Standard developed as part of the ESS project.</td><td>Greg Szuch, P. Eng.</td></tr>
</table>

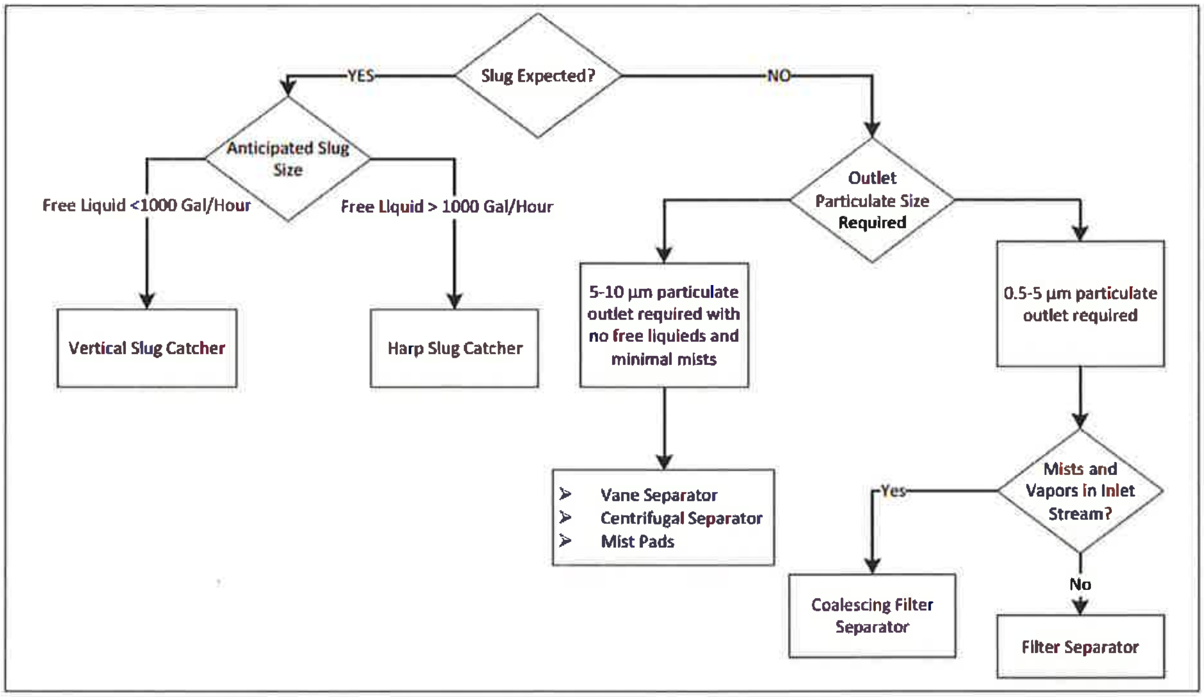
17 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
N/A	This Standard is a new document.

18 APPROVALS

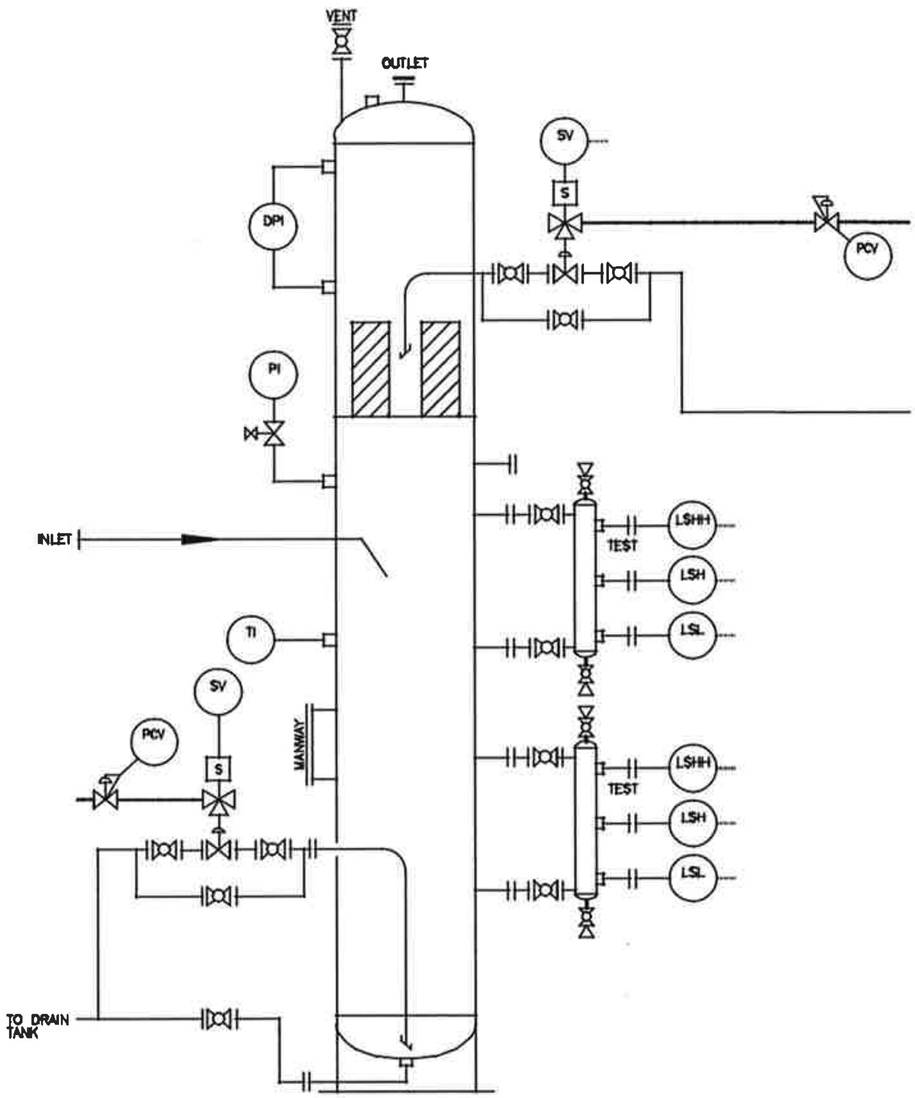
APPROVALS		
Originator: Greg Szuch, P. Eng. Facility Integrity Engineering	Signature	Nov 28, 2017 Date
Reviewer: David Thom, P. Eng. MX - Engineering	Signature	DEC 7, 2017 Date
Reviewer: Molly Beckel, P. Eng. CGO TS – Engineering Support	Signature	NOV 29, 2017 Date
Reviewer: Robert Rushman, P. E. USTS Compression West	Robert A. Rushman Signature	11/28/2017 Date
Reviewer: Jose Jairzinho Cervantes Herrera MGO Asset Reliability & Performance	Signature	06/Dec/2017 Date
Reviewer: Steven Foo, P. Eng. CGO Compression Engineering	Signature	DEC. 6, 2017 Date
Responsible Engineer: Greg Szuch, P. Eng. Facility Integrity Engineering	Signature Dec 11, 2017 Date	PROFESSIONAL ENGINEER GREGORY C. SZUCH ALBERTA APEGA Permit to Practice P7100
Management Endorsement: Muhammad Riaz, P. Eng., Manager Engineering Standards Governance	on behalf of Riaz Signature	Dec 12, 2017 Date

APPENDIX A FLOW CHART FOR FILTRATION SELECTION GUIDANCE



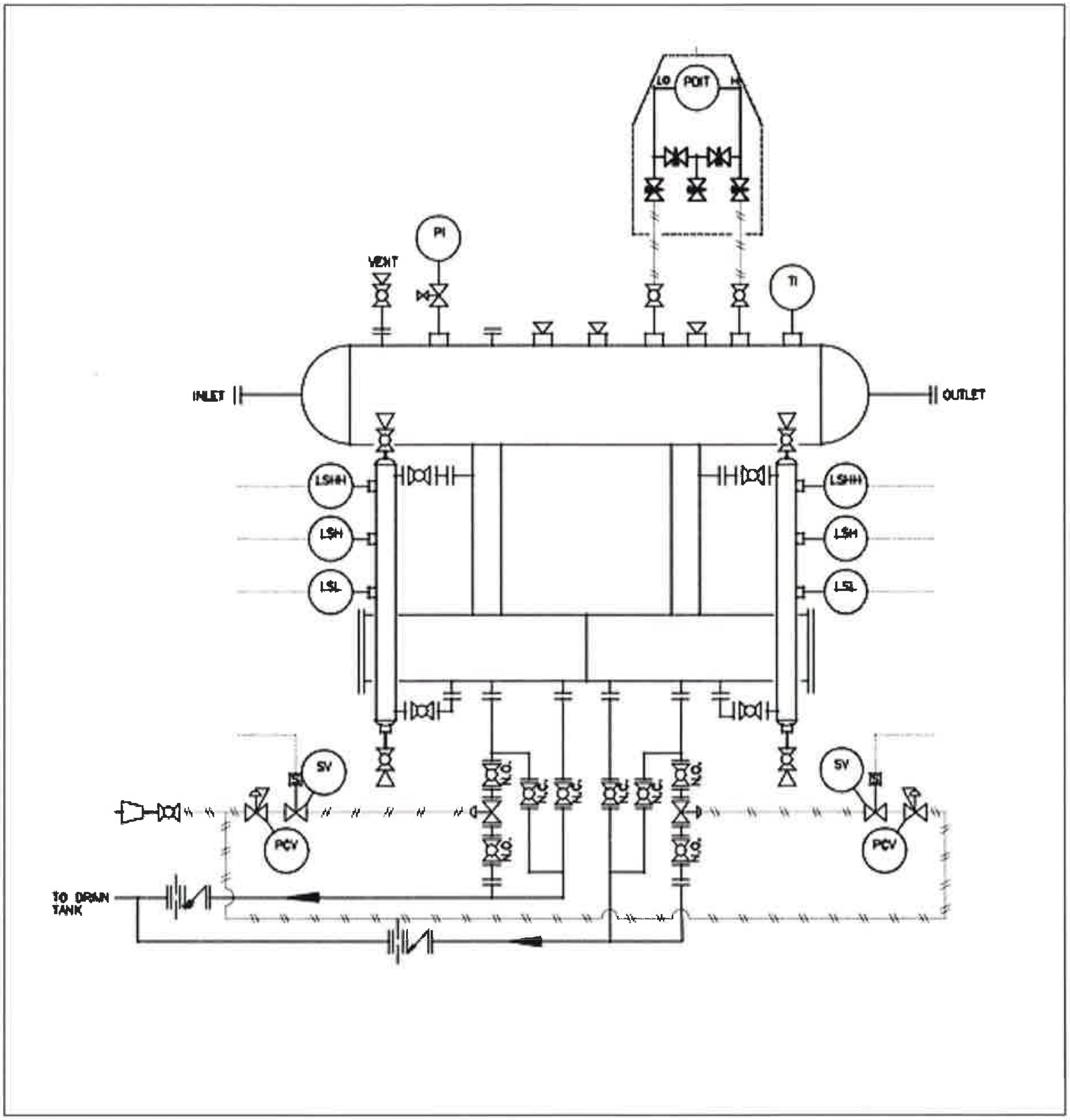
Appendix Figure A-1: Flow Chart for Filtration Selection Guidance

APPENDIX B SLUG CATCHER



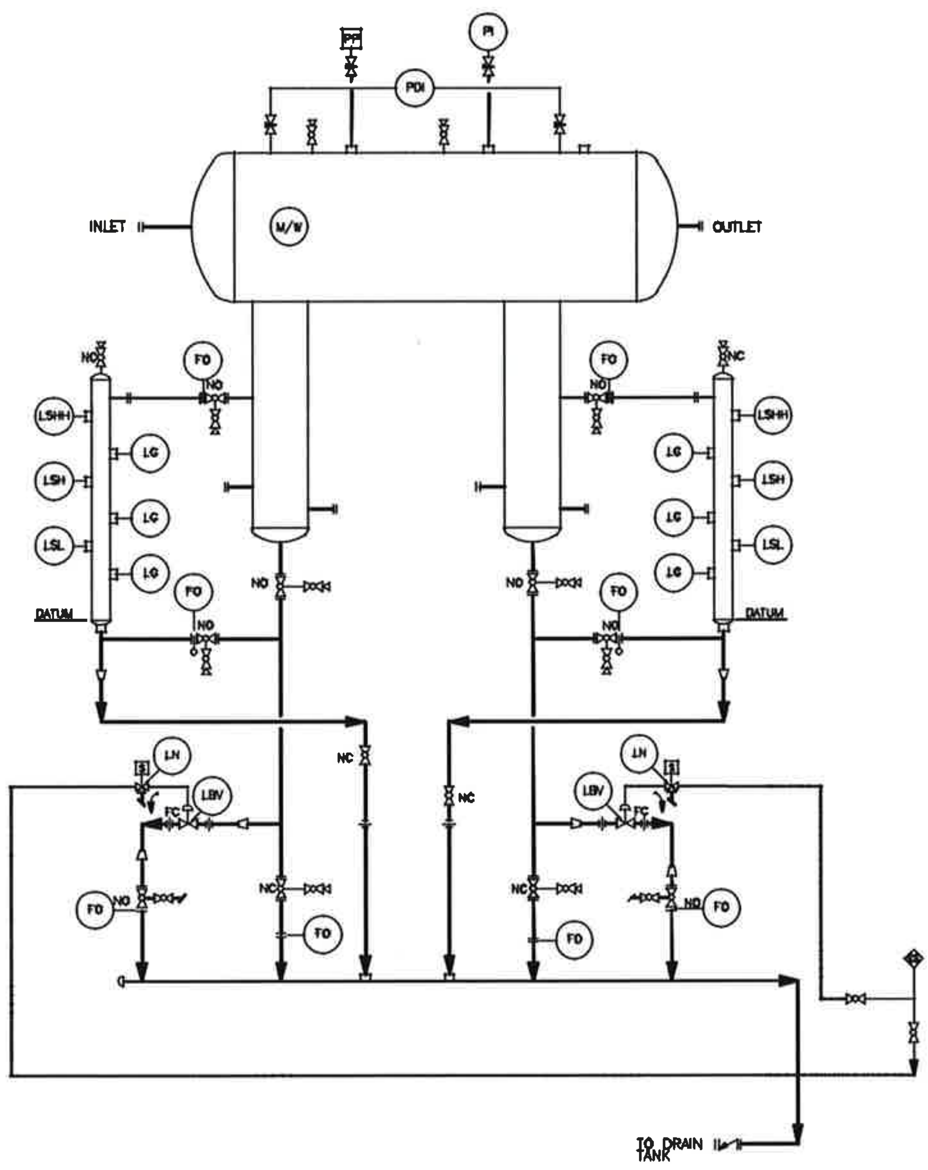
Appendix Figure B-1: Slug Catcher

APPENDIX C HORIZONTAL FILTER/SEPARATOR



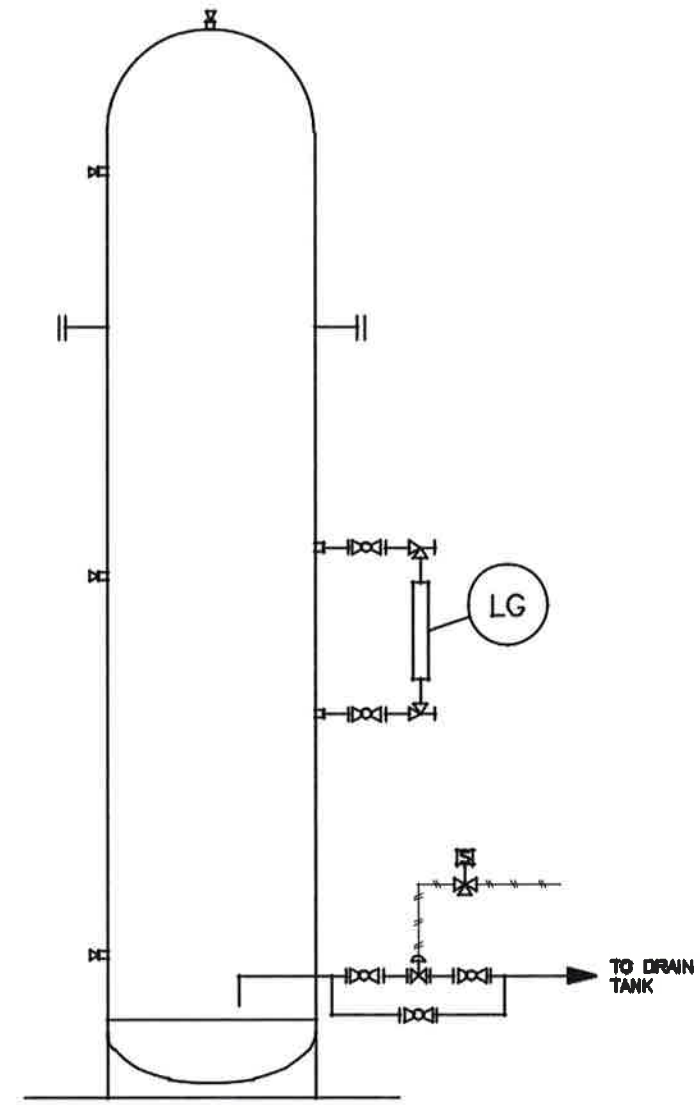
Appendix Figure C-1: Horizontal Filter/Separator

APPENDIX D SCRUBBER/SEPARATOR



Appendix Figure D-1: Scrubber/Separator

APPENDIX E VERTICAL SEPARATOR



Appendix Figure E-1: Vertical Separator

PURPOSE

The purpose of this Specification is to provide Company requirements for welding pipelines and facilities.

SCOPE/APPLICABILITY

This Specification describes the technical requirements for qualification of welding procedures, welders, production welding, visual and nondestructive examination, and repair welding for welds in hazardous liquids and gas pipeline systems in the United States (U.S.) and Mexico. The requirements in this Specification apply to both Company employee welders and welders employed by contractors or sub-contractors.

This Specification shall be read in conjunction with American Petroleum Institute (API) 1104 and covers additional requirements of 49 Code of Federal Regulations (CFR) 192 for natural and other gas pipelines and 49 CFR 195 for hazardous liquids pipelines.

This Specification applies to pipelines and facilities (i.e., compression, meter and pump facilities), and to welds made using welding procedures qualified in accordance with the requirements of API 1104 and American Society of Mechanical Engineers (ASME), Section IX, as appropriate.

This Specification does not apply to welds for:

- in-service piping that are covered by Company Specification *TES-WL-APIIS-GL Welding on In-Service Pipelines Specification (US-MEX)* (EDMS no. 6717380)
- pressure vessel or storage tank fabrication covered by ASME, Section IX
- structural welds that fall under the jurisdiction of AWS D1.1

Contact the Responsible Engineer for clarification if needed.

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1 GLOSSARY

API

American Petroleum Institute

ASME

American Society of Mechanical Engineers

ASTM

American Society for Testing and Materials

AUT

Automated Ultrasonic Testing

AWS

American Welding Society

CFR

Code of Federal Regulations

Company

TransCanada, as well as all partially owned entities and/or joint ventures where TransCanada has operational control.

CSA

Canadian Standards Association

CVN

Charpy V-notch

FCAW

Flux-cored Arc Welding

GMAW

Gas Metal Arc Welding

GTAW

Gas Tungsten Arc Welding

HAZ

Heat-affected Zone

MCAW

Metal Cored Arc Welding

MTR

Material Test Report

NDE

Nondestructive Examination

NDT

Nondestructive Testing

PQR

Procedure Qualification Record

PWHT

Post-weld Heat Treatment

SAW

Submerged Arc Welding

Shall

A mandatory requirement.

Should, May

A recommended or suggested practice.

SMAW

Shielded Metal Arc Welding

SMYS

Specified Minimum Yield Strength

WPDS

Welding Procedure Data Sheet

WPS

Welding Procedure Specification

2 REQUIREMENTS

2.1 General Requirements

2.1.1 Wherein the Manufacturer's literature, governmental or regulatory requirements conflict with this Specification, the more stringent requirement shall govern.

2.1.2 Unless specified, all statements in this Specification are requirements.

2.1.3 Unless specified, the Contractor and/or internal welding departments are the subject for all requirements included in this Specification.

2.2 Weld Design—General

2.2.1 Perform all welding, including tack welds, temporary welds and utility piping welds, using qualified welding procedures as provided in the Project Welding Plan and approved for use by Engineering.

2.2.2 Use welders who are qualified to use the specific welding procedure.

2.2.3 For projects overseen by Construction Management Services, a Welding Inspector will be assigned to witness all welding of process, gas transmission, hazardous liquid, or other types of pressurized piping including temporary welds.

2.2.4 For projects completed by Operations and Maintenance, welding inspection will be performed as per *TES-WL-INSPQ-G Welding Inspector Qualification for Operations and Maintenance Related Work Specification (US)* (EDMS no. 1004847508).

2.2.5 The Welding Inspector checks certification records for each welder working on Company projects to assure that proper and current qualification data is on file and is appropriate for the welding to be performed. Welder documentation is to be placed into the project file.

2.2.6 For pipeline and pump station applications, the Welding Inspector ensures that no welder welds piping unless the welder has both:

- successfully completed a qualification weld in accordance with either API 1104 or ASME BPV, Section IX (as appropriate for the work to be performed)
- had a weld tested either:
    - destructively, in accordance with API 1104 or ASME IX, as appropriate
    - nondestructively, in accordance with API 1104, with prior written Engineering approval

2.2.7 For facility (i.e., compression, metering) applications, the Welding Inspector ensures that no welder makes any weld unless the following conditions have been met:

- The welder has made a weld in accordance with either API 1104 or ASME BPV, Section IX (as appropriate for the work to be performed).
- The welder has had it destructively tested either to the requirements of API 1104 or ASME IX, as applicable.

2.3 Weld Design—Design Temperature

2.3.1 Qualify welding procedures at or below the pipeline/facility minimum design temperature. Unless otherwise specified, minimum design temperatures are:

- 32°F (0°C) for welds in buried pipelines (depth of cover two feet or greater)
- either -20°F (-29°C) or -49°F (-45°C) for above-grade facilities and facilities with less than two feet of cover, depending on location

Refer to *TED-MATL-FRAC Materials Fracture Control Plan* (CDN-US-MEX) (EDMS no. 7076183) for the design temperature zone map.

2.3.2 Minimum design temperature shall be shown on the appropriate Welding Procedure Specification (WPS).

2.4 Welding Procedures—General

2.4.1 Use the following processes, or combinations thereof, for welding procedures:

- Shielded Metal Arc Welding (SMAW)
- Gas Metal Arc Welding (GMAW)
- Pulsed Gas Metal Arc Welding (GMAW-P)
- Gas Tungsten Arc Welding (GTAW)
- Flux-Cored Arc Welding (FCAW)
- Metal-Cored Arc Welding (MCAW)
- Submerged Arc Welding (SAW)

2.4.2 Other welding processes may be used if approved by the Company.

2.4.3 If inconsistencies between this Specification and a WPS are found, the WPS shall govern unless specifically noted in the text of this Specification.

2.4.4 Welding Engineering shall be alerted to any conflicts other than those where an authorized Company representative is given the authority to make this type of decision.

2.5 Welding Procedures—Application Method

2.5.1 Weld deposition can be manual, mechanized or semi-automatic.

2.6 Welding Procedures—Recommended Combinations

2.6.1 Welding process selection and acceptable combinations of processes for pipe with a specified minimum yield strength (SMYS) greater than or equal to API 5L X60 are listed in Appendix B.

2.7 Welding Procedures—Additional Requirements

2.7.1 Make fillet welds using low-hydrogen welding consumables. The first pass may be applied with cellulosic consumables.

2.7.2 For material grades of 60,000 psi SMYS and below:

- Where design temperature is -49°F (-45°C) and/or nominal wall thickness is greater than 0.750 in. (19.1 mm), complete fill and cap passes with low hydrogen consumables in accordance with the appropriate WPS.
- Except where the piping is internally cleaned after welding, complete the root pass of butt welds in lube oil piping using GTAW and bare consumables.
- Cellulosic electrodes may be used for the root pass of through-wall repairs; complete all remaining passes on repair welds using low-hydrogen consumables.
- Make all back welds, including repairs, using low hydrogen consumables.

2.7.3 For material grades of 65,000 and 70,000 psi SMYS:

- Where design temperature is -49°F (-45°C) and/or nominal wall thickness is greater than 0.750 in. (19.1 mm), complete fill and cap passes using low-hydrogen consumables in accordance with the appropriate WPS.
- Girth welds involving a component where design temperature is 32°F (0°C) or -20°F (-29°C) may be welded using cellulosic consumables provided that all of the following conditions are met:
  - the CE value, defined in CSA Z245.1, of the component is less than 0.43%

    Note:

    If the CE value of the component is unknown, cellulosic electrodes may be used for the root/hot passes and low hydrogen consumables shall be used for fill and cap passes.
  - the nominal pipe wall thickness is less than 0.750 in. (19.1mm)
  - the ambient temperature at the time of welding is greater than the design temperature
- Cellulosic electrodes may be used for the root pass of through-wall repairs; complete the remaining passes on repair welds using low-hydrogen consumables.
- Make back welds, including repairs, with low-hydrogen consumables.

2.8 Welding Procedures—Joint Design

2.8.1 Butt Welds

- Ensure bevel angles are 30° -0/+5°, unless otherwise specified, and all field cuts are 90° to the pipe axis.
- Between pipes of unequal nominal wall thickness, make butt welds using a transition designed in accordance with the requirements of Company Procedure *TEP-MECH-TRAN-US Selection of Transition Pieces and Joining Methods* (EDMS No. 5695478).

- Make mechanized GMAW butt welds using a narrow gap bevel configuration. Mechanized welding systems can use either an automated internal welding system and clamp, or an internal clamp with a copper backing ring with an external mechanized welding system to make the root weld.
- Miter joints are prohibited. A deflection up to 3° caused by misalignment is not considered a miter joint. Multiple deflections each less than 3° cannot be combined to produce a bend.
- The use of backing rings and/or backing welds is prohibited.

2.8.2 Fillet Welds

- Except where specified by the design, do not use socket coupling fillet welds to join piping larger than NPS 2 (60.3 mm OD).

2.8.3 Tack Welds in Fabrication

- A qualified welder or welding operator makes tack welds (using an appropriate, approved welding procedure) within the weld bevel area. Place a minimum of four tack welds equidistant around the pipe circumference. The Contractor/Fabricator assesses weight and size of the fabricated assembly to determine the appropriate length of tacks required to safely move and support it.
- Make tack welds at the root using filler metal with equivalent mechanical properties to that of the root pass, and then either fuse it to the root pass weld or remove it ahead of welding the root.
- Remove bridge tacks (above the root) ahead of welding the root pass.
- Tack welds follow the preheat requirements outlined in the applicable WPS.

2.9 Welding Procedures—Materials

2.9.1 Pipe and Components

- Weld materials according to their P-Number and Group Number, as given in ASME Section IX, or the base material groupings as given in API 1104. Materials that do not conform to the P-Number and Group Numbers specified by ASME Section IX are considered to be unassigned. Do not use unassigned base metals, as described in ASME BPVC Section IX, Clause QW-424.
- Weld materials listed in API 1104 according to their SMYS in one of the following groupings:
    - SMYS less than or equal to 42,000 psi
    - SMYS greater than 42,000 psi and less than 65,000 psi
    - Each material with SMYS greater than or equal to 65,000 psi requires a separate qualification
- Clearly identify all materials to be welded and ensure the Manufacturer's material test reports (MTR) are included in the project record.

2.9.2 Filler Metals

- Select or combine filler metals that have yield and tensile properties on the completed/combined deposit weld to match or exceed yield and tensile strengths for the materials being welded. All FCAW consumables require Company approval prior to use. Random destructive testing may be implemented for FCAW and MCAW wire consumables on a batch number basis.
- Store and handle filler metals and fluxes to avoid damage to them and to their shipping containers. Protect consumables in opened containers from deterioration and protect coated filler metals from excessive moisture changes. Discard filler metals and fluxes that show signs of damage or deterioration.
- Keep low-hydrogen type covered electrodes in hermetically sealed, moisture-proof containers until ready for use. After opening, store low-hydrogen electrodes in appropriate holding ovens. AWS A-5.1 suggests holding oven temperatures should be in the range of 50°F to 250°F (30°C to 120°C) above ambient temperature, or per the Manufacturer's recommended holding temperature.
- Contractors and the Company's Construction department shall have a welding consumable handling and storage plan in place. If no such plan is in place, follow the requirements of *TEP-WELD-SC Storage and Control of Welding Consumables* (EDMS no. 8816242).
- Holding ovens are for low hydrogen electrodes only. Do not store other types of electrodes (e.g., cellulosic) in holding ovens.

2.10 Welding Procedures—Shielding Gases

2.10.1 Ensure components of shielding gases have a purity of at least 99.5% and a dew point of -30°F (-35°C) or lower. Make certificates of conformance of the shielding gases available to the Company upon request.

2.11 Welding Procedure Qualifications—General

2.11.1 Qualify WPS, other than those previously qualified and provided by the Company, in accordance with the requirements of API 1104 or ASME Section IX, along with the additional requirements of this Specification.

2.11.2 For qualification welds, record welding parameters on each pass. Record details of the welding procedure qualification tests required by API 1104 or ASME IX (as appropriate), and this Specification. Make the WPS and copies of the procedure qualification records (PQRs) available for review by the Company.

2.11.3 Welding procedures are reviewed and approved by Engineering prior to the start of welding.

2.11.4 The Company requires separate repair welding procedures when procedure qualification is to API 1104. See section 2.54 of this Specification.

Note:

In accordance with ASME BPV Code Section IX, WPS and welding procedure qualifications are the sole ownership of the company or entity that develops the procedures and employs the welders. This weld documentation is non-transferable between unaffiliated companies. Therefore, Company ASME IX WPS are only be used by internal Company-employed welders. Contractor welders cannot use Company ASME IX Welding procedures.

2.12 Welding Procedure Qualifications—Additional Essential Variables

2.12.1 WPS are limited by the following additional essential variables:

- changes to pulse parameters or pulsed software version from those used on qualification weld (i.e., modified wave form GMAW, such as controlled-dip and pulsed)
- change to a minimum design temperature lower than impact toughness testing temperature during procedure qualification

2.13 Welding Procedure Qualifications—Test Weld Acceptability for Destructive Testing

2.13.1 Ensure test welds meet the visual inspection requirements given in section 2.51 of this Specification.

2.13.2 Only subject procedure qualification welds to nondestructive examination (NDE) to determine if the weld is acceptable to API 1104 criteria. Do not use NDE to determine locations of destructive test coupons.

2.13.3 If test welds fail to meet visual inspection requirements, stop procedure qualification, do not proceed with destructive testing, and initiate new test welds for qualification.

2.14 Welding Procedure Qualifications—Impact Toughness Testing

2.14.1 Test one set of three Charpy V-notch specimens from each of the weld metal and heat-affected zones (HAZ) in accordance with the requirements of ASTM E 23.

- Perform testing at a temperature at or below the minimum design temperature.
- When the weld joins different material types or grades, take one set of Charpy specimens from each HAZ of the parent metals.

2.14.2 When post-weld heat treatment (PWHT) is used in the welding procedure, test additional specimens of parent metals in the PWHT condition.

2.14.3 The minimum average absorbed energy value of the Charpy V-notch testing for three full size (10 mm x 10 mm) specimens is 20 ft.-lbs. (27 J). Only one absorbed energy value may be below the minimum of 20 ft.-lbs. (27 J) and the minimum absorbed energy value is 15 ft.-lbs. (20 J). Proportional reduction of this minimum absorbed energy requirement for sub-sized specimens is permissible. Do not lower the minimum absorbed energy requirement based upon reduced test temperature.

2.14.4 Record test values, including percent shear and lateral expansion (for information only).

2.15 Welding Procedure Qualifications—Tensile Testing

2.15.1 Follow the requirements in API 1104, Section 5.6: Testing of Welded Joints – Butt Welds.

2.15.2 All-weld metal tensile testing may be required for welding consumables used on materials with SMYS greater than or equal to 70,000 psi (API 5L PSL 2 X70).

2.15.3 Record test values and failure locations on the procedure qualification record.

2.16 Welding Procedure Qualifications—Hardness Testing

2.16.1 For carbon steel welds, ensure the welding procedure qualification records include macroindentation hardness traverses across the weld, HAZ, and parent metal, as shown in Figure 2-1.

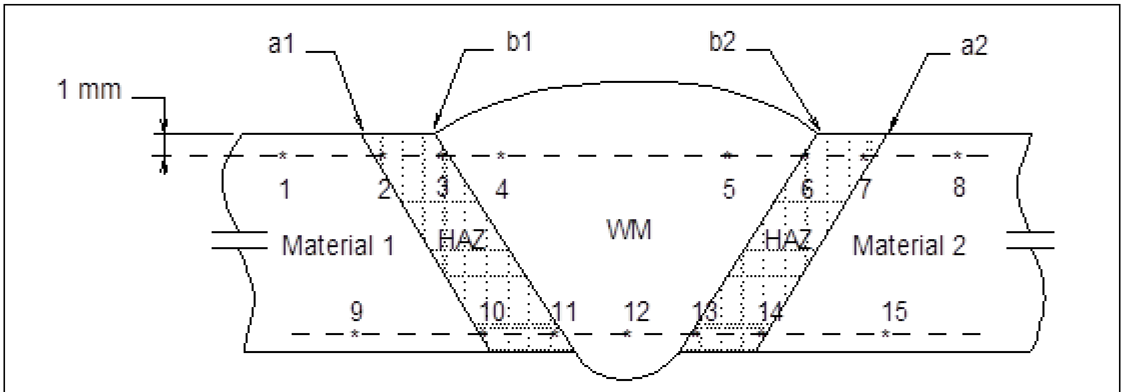
- Hardness impressions 3, 6, 11 and 13 should be entirely within the HAZ, as close as possible to the fusion boundary.
- Impressions 2 and 7 should also be within the HAZ.

2.16.2 Perform macroindentation hardness tests in accordance with ASTM E384 for Vickers testing (maximum 10 kg load) or ASTM E18 for superficial Rockwell testing. Ensure the maximum HAZ hardness is 350 HV10, 77 HR 15-N, or 55 HR30-N (see ASTM E18, Table A5.3 for approximate conversions).

2.16.3 Do not convert hardness readings from one hardness scale to another.

2.16.4 Report hardness measurements without converting lab results.

2.16.5 Record the measured hardness values of the base metals, HAZ, and weld metal on the procedure qualification record.



Lines a1 and a2 illustrate the boundary visible after etching between HAZ and unaffected parent metal.
Lines b1 and b2 illustrate the boundary visible after etching between weld metal and HAZ.

Figure 2-1: Vickers Hardness Traverse Locations

2.17 Welding Procedure Qualifications—Additional Testing for Alternate Acceptance Criteria

2.17.1 Where an alternate acceptance criterion is specified for NDE of production welds, conduct additional mechanical testing at a temperature not higher than minimum design temperature in accordance with API 1104, Appendix/Annex A.

2.17.2 The average value of the Charpy V-notch absorbed energy reading is a minimum of 30 ft.-lbs. (40 J). Ensure the minimum energy value for any one specimen is not less than 20 ft.-lbs. (27 J).

2.17.3 The Company reviews and accepts crack tip opening displacement (CTOD) testing. Perform CTOD testing at a facility approved by the Company. Ensure the minimum CTOD value of all six specimens is greater than 0.002 in. (0.05 mm).

2.18 Welding Procedure Qualifications—Mechanized Welding

2.18.1 Qualify mechanized GMAW welding procedures in accordance with API 1104 and Company Engineering Procedure *TEP-WELD-QUAL-MECH Qualification Procedure for Mechanized Welding Procedure Specifications (CDN-US-MEX)* (EDMS no. 7169231).

2.19 Welder Qualifications—General

2.19.1 Ensure each welder producing welds is entitled to work in the jurisdiction where the work is performed. For example, the State of Oklahoma requires welders to be licensed by the state to weld pressure piping. Similar requirements could be in effect in other states.

2.19.2 Do not use a welder's first production weld for welder qualification. Qualify welders on a test coupon prior to commencement of production welding.

2.19.3 Assign welders a unique symbol for the purpose of identification on all welds. Once a symbol is assigned to a welder, do not reassign it to another welder during the Project. It is recommended to use the welder's initials combined with the last four digits of their Social Security Number (e.g., JJ-1234).

2.19.4 Conduct qualification of welders in the presence of a Company representative.

2.19.5 Repair welder qualifications are determined according the applicable code of construction.

2.19.6 API 1104 Welder qualifications performed for companies other than TransCanada will not be considered. ASME Section IX welder qualifications may be considered (see section 2.22 of this Specification).

2.20 Welder Qualifications—Mechanized GMAW

2.20.1 Ensure welding operators complete a Contractor-developed training program accepted by the Company to ensure a suitable level of competence with the welding process, equipment and technique. The training program should be agreed upon and established with the supplier of the automatic welding equipment.

2.20.2 Use single qualification for mechanized GMAW when the NDE method for the project is AUT. Use both AUT and RT for welds meeting the requirements of API 1104, Section 9.

2.20.3 For mechanized GMAW, qualify welding operators in accordance with API 1104, Section 12.6.

2.20.4 Welding operators may be qualified for all passes (except the root pass) using mechanized welding equipment to produce a half-circumference test weld (with the root pass being made by other welders).

2.20.5 Qualify welding operators on the maximum wall thickness they will encounter on the Project.

2.21 Welder Qualifications—API 1104 SMAW

2.21.1 Qualify welders in accordance with the requirements of the API 1104, Section 6, Multiple Qualification Test. Appendix A of this Specification provides guidance on conducting qualification welds.

2.21.2 Welders who can produce proof of appropriate, current qualification by the Company in accordance with the requirements of API 1104 for a given process may be exempted from re-qualification, provided that within the preceding six calendar months they have engaged in welding with that process and had one weld tested and found acceptable under API 1104, Section 9.

- Document such tests using *TEF-WELD-QUA-US Welder Qualification Form – API 1104* (EDMS no. 4470567).
- Ensure radiographic inspection reports clearly identify the welder, date of welding and disposition to API 1104.

2.21.3 Single qualification of welders may be considered on a per project basis with prior written approval from Engineering.

2.22 Welder Qualifications—ASME Section IX

2.22.1 If welders employed by the Company are required to fabricate welds to the ASME IX Code using a qualified WPS, Engineering will provide guidance on performing the qualification welds.

2.22.2 Contractors using their own ASME IX qualified WPS are accountable to qualify their welder and maintain welder qualifications as part of their quality program. Such welder qualifications shall be current and appropriate for the welding to be performed.

2.23 Welder Qualifications—Records of Qualified Welders and Welding Operators

2.23.1 A Construction Management Services representative or their designee (i.e., Sr. Welding Inspector, Chief Inspector) will review all welder/welder operator qualification reports prior to the start of production welding.

2.23.2 Develop and maintain a list of qualified welders for the Project.

2.23.3 Make welder/welder operator qualification records available to the Company, and submit them as part of Project documentation. The Company reserves the right to request a requalification if there is any reason to question welder/welder operator ability.

2.24 Weld Execution—General

2.24.1 During construction, ensure copies of the welding specifications are available for reference at the local work site where the welding is performed.

2.25 Weld Execution—Compliance with Specifications

2.25.1 Maintain records of welding parameters (e.g., amps, volts, travel speed) used for production welding to demonstrate compliance with requirements of this Specification and the WPS. Ensure such records are available to the Company upon request.

2.25.2 The Company reserves the right to measure welding parameters on any production weld. When parameters measured on a weld do not comply with the specified values, the Company reserves the right to reject such welds and any weld made after the last compliant record, unless the party responsible for the work can demonstrate that such welds are in full compliance with the WPS.

2.25.3 Non-compliance with the requirements of API 1104 or ASME IX (as appropriate), this Specification, or the WPS is cause for weld rejection.

2.25.4 If the Company identifies an unacceptable weld repair rate, the welding contractor will submit a remedial plan that includes quality checks such as welder retraining, root cause analysis of weld defects, and welding process improvement.

2.26 Weld Preparations—Cleaning of Pipe Ends

2.26.1 Clean areas to be welded (including the weld bevel and both internal and external pipe surface in the vicinity of the weld) to a minimum distance of 1 in. (25.4 mm) from the ends of the pipe, so they are free of oxides or other extraneous matter.

2.26.2 Grind flame-cut bevels prior to welding. Ensure bevel surfaces are smooth and free of irregularities that could adversely affect the welder’s ability to produce high quality welds.

2.27 Weld Preparations—Pipe Identification

2.27.1 Where a pipe is cut, transfer pipe identification (such as pipe number, grade, heat number, Company purchase order and Manufacturer) to both ends of the pipe. It is recommended that this identification also be placed on the pipe ID surface, where possible.

2.27.2 Do not die stamp the pipe or weld for pipe identification or any other purpose.

2.28 Weld Preparations—Base Metal Examination

2.28.1 When tie-in welds are made to existing pipe or facilities, the pipe shall be examined for lamination and/or other injurious conditions that could affect welding (internal corrosion, inclusions, etc.). This examination shall be performed over the entire 360° circumference for a 12 in. (305 mm) width, centered at the proposed weld location, using visual testing and straight beam ultrasonic testing. An ultrasonic thickness gauge is acceptable for base metal examination, with preference given to an ultrasonic flaw detector with an “A” scan display. Determine the weld location before cutting the pipe.

2.28.2 Once the straight beam ultrasonic examination has been completed, examine the prepared weld bevel using magnetic particle inspection. Lamination or other mid-wall conditions (at or near the bevel that could affect the completed weld) having a circumferential length greater than 0.250 in. (6 mm) are classified as defects. Cut back the piping until no deleterious condition is present at the weld bevel area.

2.28.3 Features determined to be internal corrosion greater than 10 percent of nominal pipe thickness shall be directed to a Corrosion Specialist for disposition.

2.29 Weld Preparations—Grinding of Seam Welds

2.29.1 For welds subject to NDE using radiography, grind the pipe seam welds flush (-0, +1/32 in.) for a minimum distance of 1 in. (25.4 mm) from the bevel edge (internally and externally), with a gradual transition to the weld reinforcement.

2.29.2 For welds subject to NDE using ultrasonic examination, grind the pipe seam welds flush (-0, +1/32 in.) for a minimum distance of 4 in. (100 mm) from the bevel edge (internally and externally), with a gradual transition to the weld reinforcement.

2.30 Weld Preparations—Alignment and Fit-Up

2.30.1 Do not use miter joints. (Deflections up to 3° caused by misalignment are not considered miter joints.)

2.30.2 Minimize external forces required to align pipes. If pipes to be joined are in place:

- Below grade, expose a sufficient length of each end of the pipes so each can be moved without imposing detrimental external stresses at the joint. If the Company welding representative determines that external stress has been put on the weld, a 24-hour delay prior to NDE will be enforced.
- When there is not sufficient length to allow free movement, consultation with the onsite Company representative to determine the appropriate course of action is required. This may include having to cut and reinstall the pipe to bring the misalignment within tolerance. See section 2.30.11 for guidance.

2.30.3 For buried piping, except in the case of bends, stagger longitudinal seam welds on adjacent pipe at approximately the 10 o'clock and 2 o'clock positions.

2.30.4 On longitudinal seam welded pipe, place the seam at right angles ±10° to the plane of bending. On combination bends, this may not be achievable and the Project or Design Engineer shall be contacted for guidance.

2.30.5 For above grade piping, locate the seam weld as to not interfere with possible branch connections at the 12, 3, 6 or 9 o'clock positions.

2.30.6 Where two seam welds on adjacent pipes meet at a common girth weld, offset the two seams by a minimum distance of 2 in. (50 mm) from each weld toe. Aligned seams on either side of a girth are acceptable only when a fabricated assembly has been cut for transportation purposes and will be reassembled on site.

2.30.7 Any branch attachment shall be located a minimum of 2 in. (50mm) (toe-of-weld to toe-of-weld) from any girth weld or pipe seam weld.

2.30.8 Do not locate pipe seam welds on top of any pipe support (i.e., beam or concrete support).

2.30.9 Do not hammer pipe. (Use of a small hard plastic or steel hammer to signal release of internal clamps is acceptable as long as there is no damage to the pipe surface or adjacent coating). Where external line-up clamps are used, correct minor out-of-roundness and misalignment using wedges.

2.30.10 Line-up clamps are to have approximately equally spaced pressure points around the surface of the pipe.

2.30.11 Line-up clamps selected for the job must be of the size and type capable of holding and maintaining the proper line up of the joint to be welded. They shall be capable of removing out-of-roundness permitted in pipe manufacture to within the tolerance permitted in section 2.30.12. For shop fabrication, other acceptable line-up devices/techniques may be substituted, if acceptable to the Company representative.

- On new mainline construction, the use of internal line-up clamps is preferred for mainline pipe-to-pipe welds. Approval for use of external clamps shall be obtained from the Project Construction Manager.
- For tie-ins, maintenance projects and facility construction, external clamps may be used.

2.30.12 For pipe-to-pipe welds of the same nominal wall thickness, do not exceed the maximum offset or misalignment of the abutting pipe ends, as follows:

- $\leq$ 0.250 in. (6.4 mm) do not exceed 1/16 in. (1.6 mm)
- > 0.250 in. (6.4 mm) to 0.500in. (12.7 mm) do not exceed 3/32 in. (2.5 mm)
- > 0.500 in. (12.7 mm) do not exceed 1/8 in. (3.2 mm)

2.30.13 For pipe-to-component joints of equal nominal wall thickness, do not exceed 1/8 in. (3.2 mm) external offset. Ensure internal offsets exceeding 3/32 in. (2.4 mm) conform to the conditions specified in section 2.43 of this Specification.

2.30.14 Fully insert pipe into Sockolet fittings, ensuring a gap of 1/16 in. (1.2 mm) between the pipe and the bottom of the Sockolet. Gapolets are an acceptable means of maintaining the gap requirements.

2.30.15 Segmentable fittings must have a minimum arc length measured along the crotch, as per Table 2-1.

Table 2-1: Minimum Arc Length for Segmentable Fittings

NPS (in.)	Min. Allow. Angle (Deg) Std. Rad.	Min. Allow. Angle (Deg) Short Rad.	NPS (in.)	Min. Allow. Angle (Deg) Std. Rad.	Min. Allow. Angle (Deg) Short. Rad.
2	31	70	12	5	10
3	20	45	14	4	8

NPS (in.)	Min. Allow. Angle (Deg) Std. Rad.	Min. Allow. Angle (Deg) Short Rad.	NPS (in.)	Min. Allow. Angle (Deg) Std. Rad.	Min. Allow. Angle (Deg) Short. Rad.
4	16	32	16	3	7
6	10	21	18	3	6
8	7	15	20	3	5.5
10	6	12	≥24	3	5

2.31 Special Pipeline Applications

2.31.1 For all welding on coupled pipelines, a technical welding support person shall be consulted prior to any production welding.

2.31.2 For all welding on well casing pipelines, the Company has established WPS ASME-GW-01. However, casing materials are significantly more variable than standard pipe material and caution must be used when applying this procedure. Contact a technical welding support person for additional guidance.

2.32 Weld Preparations—Pipe Support

2.32.1 Do not weld supports, bracing bars or counter balance weights to pressure piping and components.

2.32.2 Ensure pipe is supported in accordance with standard industry practice. Report any occurrence of a section of line falling from its support to the Company, together with any tests, inspections and remedial work performed as a result of the fall. The Company determines whether the piping is acceptable for use.

2.33 Weld Preparations—Weather Conditions

2.33.1 Protect welds during welding from weather conditions considered detrimental to weld quality. Portable enclosures may be used to make conditions satisfactory for welding.

2.33.2 Wrap the completed weld in a clean, dry welding blanket when ambient temperature at the time of welding is below 50°F (10°C). Remove the blanket once the weld area reaches ambient temperature.

2.34 Weld Preparations—Grounding and Cables

2.34.1 Securely attach grounding devices in a manner to prevent arc burns. Do not weld grounding devices to pipe, or place on the pipe body. Preferably, make contact within the weld groove and ensure the grounding device is large enough to prevent local overheating or arcing (i.e., minimum 0.5 in. (12.7 mm) wide and 1/8 in. (3.2 mm) thick). Ensure devices grounding in the bevel area are made of steel. Do not use copper or bronze tips for such purpose.

2.34.2 The use of magnetic ground clamps is prohibited.

2.34.3 Ensure welding cables, ground clamps and connections are insulated to prevent arcing to the pipe surface. Avoid ground paths through valves.

2.35 Weld Preparations—Protection of Coatings

2.35.1 Protect existing coatings on piping to minimize damage that may result from the welding operations. Following the root pass, the top third of the pipe is to be protected from welding spatter any time the welder is working in that section.

2.36 Weld Preparations—Preheating and Controlled Cooling

2.36.1 Unless otherwise specified on the welding procedure, use the preheat temperatures given in Table 2-2.

2.36.2 Preheating of material should be done by one of the following methods:

- Electrical Resistance or Induction Heating.
- Gas Torch, where two torches are required for NPS 16 and larger piping. Care shall be exercised to raise the temperature evenly around the entire circumference of the joint.

2.36.3 Apply preheat for a minimum distance of:

- 3 in. (76.2 mm) to each side of the weld for the full circumference, in the case of girth welds
- 5 in. (127 mm) from any point of the area to be repaired, in the case of repairs

2.36.4 Maintain minimum preheat temperatures until the completion of all welding, except as allowed in section 2.41 of this Specification. Welds must be at the minimum preheat temperature (or higher) prior to welding each pass.

2.36.5 Welders, or welder's helpers, shall check preheat and interpass temperatures at the top, bottom and both sides of the pipe using temperature-indicating crayons or contact thermocouple probes. Ensure temperatures are within the specified limits prior to the start of welding. Infrared pyrometers may be used by inspection staff for quality control checks, but shall not be used as the final determination of preheat and interpass temperatures prior to welding.

2.36.6 Do not cool passes of a weld at a rate greater than that provided by natural air cooling.

Table 2-2: Preheating Temperatures

Application - Process - Grade	Wall Thickness (inches)	Carbon (weight %)	Minimum Preheat	Maximum Interpass
Grade X60 and lower, all processes	< 1 (25.4 mm)	≤ 0.30	125°F 50°C	450°F 235°C
		> 0.30	200°F 95°C	450°F 235°C
	≥ 1 (25.4 mm)	All	200°F 95°C	450°F 235°C

Application - Process - Grade	Wall Thickness (inches)	Carbon (weight %)	Minimum Preheat	Maximum Interpass
Grade X65 and higher, all processes	All	All	200°F 95°C	450°F 235°C
Repairs, all processes and grades	All	All	250°F 120°C	450°F 235°C
Legacy CPG Well Casing Pipe	All	All	350°F 177°C	475°F 246°C

2.37 Weld Preparations—Number of Welders

2.37.1 For pre-fabricated welds on piping greater than NPS 14 (356 mm), a minimum of two welders shall be required for the root, hot pass and first fill (if required), then one welder may complete the weld as long as pre-heat is maintained on the entire weld.

2.37.2 Tie-in welds on piping greater than or equal to NPS 14 shall be completed with two welders for the entire weld.

2.37.3 One welder is acceptable for position welds on piping less than NPS 14 and roll welds of any diameter.

2.38 Weld Preparations—Start of Welding

2.38.1 Do not commence welding until all parts to be joined are secured against movement.

2.39 Weld Preparations—Release of Line-Up Clamp

2.39.1 When using internal line-up clamps, complete the root pass for 100% of the circumference prior to release.

2.39.2 For external line-up clamps, ensure the root pass is at least 50% complete before removal of the clamp, unless stated otherwise on the welding procedure. Ensure there is no pipe movement until the root pass is 100% complete.

Note:

To minimize the risk of cracking of mainline manual welds (i.e., manual welds completed with an internal line-up clamp), it may be necessary to weld the hot pass for an approximate length of 1 ft. (305 mm) in the area of highest anticipated stresses, prior to moving the pipe. This area would typically be on the bottom of the pipe, but could be on the top of the pipe in an overbend situation, or on the sides of the pipe in a side bend situation.

2.40 Weld Preparations—Cleaning between Passes

2.40.1 Remove clusters of surface porosity, weld bead starts, high points and slag by grinding prior to depositing weld metal in subsequent passes. Clean between passes as necessary for all welding processes to ensure weld quality.

2.41 Weld Preparations—Interruptions in Welding

2.41.1 When welding less than 0.500 in. (12.7 mm) nominal wall thickness, a minimum of three passes is required prior to any interruption.

2.41.2 When welding 0.500 in. (12.7 mm) nominal and greater wall thickness, the filler passes shall be applied one after another without interruption until at least one- half the wall thickness of the welding groove is filled. An exception to this rule is allowed for standard breaks or lunch, provided the pipe is securely supported. In no case is the groove to be less than one-half-filled overnight or longer.

2.41.3 Mainline welds in a pipe laying operation shall be completed as stated on the approved WPS with a maximum to completion of 72 hours.

2.41.4 Tie-in welds shall be completed the day they are started, continuously without delay.

2.42 Weld Preparations—Bead Sequence, Width, and Capping

2.42.1 For semi-automatic/automatic processes, ensure the maximum width of any weld bead within the weld groove is 0.75 in. (19.1 mm).

2.42.2 For SMAW, ensure the maximum bead width is no more than three times the electrode diameter being used.

2.42.3 Overlap the circumferential start locations of consecutive beads by at least 1 in. (25.4 mm).

2.42.4 Ensure the toe of the completed weld is no more than 1/8 in. (3.2 mm) beyond the edge of the original groove.

2.42.5 For split weld caps and multi-pass weld caps, avoid having the edge of any bead along the weld centerline.

2.43 Weld Preparations—Back Welding

2.43.1 Backwelding using low-hydrogen consumables is permitted in any area where the internal misalignment exceeds 3/32 in. (2.4 mm).

2.43.2 Ensure welding produces a gradual transition in material thickness.

2.43.3 Remove root pass metal reinforcement in areas to be backwelded by grinding before welding.

2.43.4 The Contractor/Fabricator must have a qualified backweld procedure or request a procedure from the Company.

2.44 Weld Preparations—In-Process Repairs

2.44.1 In-process repairs may be made with Company approval using an appropriate WPS qualified for groove welds.

2.44.2 Flaws must be mechanically removed and re-welded before the weld is presented for final visual inspection.

2.44.3 In-process repairs do not count as a repair attempt for any grinding or welding on a completed weld to correct an individual defect or accumulation of defects in the weld after it has been rejected by visual examination in accordance with acceptance criteria of the appropriate standard.

2.45 Weld Preparations—Transition Welds

2.45.1 Make transition welds using a transition designed in accordance with *TEP-MECH-TRAN-US Selection of Transition Pieces and Joining Methods* (EDMS no. 5695478).

2.46 Weld Preparations—Identification of Welds and Welders

2.46.1 Mark welds with a unique identification on the top quadrant of the pipe, adjacent to each weld.

2.46.2 Welders are responsible for marking their unique welder number/letter on the top quadrant of the pipe adjacent to each weld they have worked on using a permanent marker (the use of low stress stamps is not acceptable for pressure piping).

2.46.3 Ensure welder markings are at least 3 in. (75 mm) from the edge of the coating cutback (approximately 8 in. (200 mm) from the weld centerline).

2.46.4 Record the welder identification number/letter on the weld log, NDE inspection record and relevant drawing/spool sheets.

2.47 Weld Preparations—Closure Welds

2.47.1 Submit welds that are not hydrostatically tested to in-process examination as outlined in *TEF-WELD-TIE-IN Tie-in Weld In-Process Examination Form (CDN-US-MEX)* (EDMS no. 8275922).

2.48 Weld Preparations—Weld Cleanup

2.48.1 Completely remove weld spatter, coating or loose debris from the surface of the joint for a minimum distance of 4 in. (100 mm) on each side of the weld, as required for NDE inspection.

2.49 Inspection and Nondestructive Examination of Welds—General

2.49.1 Except as noted in 2.49.2, inspect completed welds for 100% of their lengths and assess any imperfection using the applicable standard of acceptability given in section 2.53 of this Specification, as well as API 1104, Section 9. Fully document all inspections.

2.49.2 Small diameter, low pressure lines (i.e., lines that operate at a low percent SMYS) may have different inspection requirements. Refer to *TES-WL-INSP-G Minimum Weld Inspection Requirements for Small Diameter, Low Percent SMYS Piping Specification (US)* (EDMS no. 1004847597)).

2.49.3 Perform visual inspection in accordance with *TEP-NDT-VT Visual Examination (CDN-US-MEX)* (EDMS no. 7381161). Ensure the completed weld is free from cracks, inadequate penetration and burn-through, and presents a neat workman-like appearance. Ensure any undercut meets the requirements of API 1104, Table 4.

2.49.4 Document the visual inspection of each weld on the appropriate form, along with the acceptance to API 1104.

2.49.5 Welds that do not pass visual inspection in accordance with API 1104 shall not be submitted to NDE until the discrepancy has been rectified to the satisfaction of the welding inspector.

2.49.6 Use radiographic inspection (*TES-RT-API Radiographic Examination of Welds Specification (US-MEX)* (EDMS no. 4472888)) or ultrasonic inspection (*TES-UT-API Ultrasonic Examination of Girth Welds Specification (US-MEX)* (EDMS no. 1001828660)) methods, or a combination of such methods, for butt weld NDE. For welds completed using a back bevel, consider the difference in wall thickness (WT) across the weld when selecting the NDE method/technique.

2.49.7 Do not use manual ultrasonic inspection as the primary inspection method for girth welds. When used, perform manual ultrasonic inspection in accordance with the requirements of *TES-UT-API Ultrasonic Examination of Girth Welds Specification (US-MEX)* (EDMS no. 1001828660).

2.49.8 For buried service, unequal wall thickness pipe-to-pipe field welds (NPS 12 and greater) with one side having a back bevel transition, a shear wave or time-of-flight diffraction (TOFD), ultrasonic inspection shall be performed when cellulosic consumables are used and other hydrogen mitigation actions have not been implemented. This shall be a secondary inspection to screen for lack of fusion in the root or cracking. Refer to Appendix C of this specification for additional guidance regarding this secondary UT inspection. This ultrasonic inspection should be performed at least 24 hours after the weld has been completed. Alternatively, AUT can be utilized as both the primary and secondary inspection as specified in the project documents issued to the Contractor.

2.49.9 Use magnetic particle inspection for fillet weld NDE on ferromagnetic materials in accordance with API 1104 Clauses 9.4 and 11.2, as well as ASME BPVC Section V, Article 7.

2.49.10 Use liquid penetrant inspection for fillet weld NDE on non-ferromagnetic materials in accordance with API 1104, Clauses 9.5 and 11.3, and ASME BPVC Section V, Article 6.

2.49.11 Phased-array ultrasonics using an approved procedure and operators may be implemented for pipe-to-pipe butt welds, but only with prior written permission from Engineering.

2.49.12 The Company may require additional inspection with other NDE methods.

2.49.13 Inspect repair welds with the same NDE method used to identify the original defect.

2.49.14 Evaluate welds to the acceptance criteria for each relevant NDE method shown in Section 9 of API 1104.

2.50 Inspection and Nondestructive Examination of Welds—Delayed Hydrogen Cracking

2.50.1 Three main factors contribute to delayed hydrogen-induced cracking of girth welds:

- residual stresses

- hydrogen trapped in the weld
- hard, brittle microstructure in the HAZ

2.50.2 For pipeline maintenance and facility construction, Engineering evaluates the scope of work and the material being welded on the Project, and provides guidance on mitigating risks of having delayed hydrogen crack issues when welding procedures are selected. This may include delaying NDE up to 24 hours.

2.50.3 For new mainline construction (SMAW or Mechanized GMAW), Engineering works in conjunction with the Project to determine a 24-hour delayed inspection plan for both mainline and tie-in welds. This may include a specified number of welds subject to a 24-hour delayed NDE at the start of the project to verify the Contractor has an acceptable construction process in place. Ensure these requirements are included in the project documents issued to the Contractor.

2.50.4 For welds with no subsequent pressure test (i.e. tie-in welds), temperature maintenance may be required to decrease the likelihood of hydrogen cracking, and/or there may be a delay prior to inspection so the inspection can detect delayed hydrogen cracking. An inspection delay is required when a weld procedure other than API-08-GW-FTI is used and any of the following conditions exist:

- nominal wall thickness is greater than 0.375 in. (9.5 mm)
- pipe is pre-1980 vintage or unknown seam weld
- carbon equivalent is known to be greater than 0.45%
- ambient temperature is at or below 15°F (-10°C)

The inspection delay may be avoided if the requirements in WPS API-08-GW-FTI are followed and the weld area is maintained at a minimum of 250°F (120°C) for at least 15 minutes after welding is completed and before the weld has cooled.

2.51 Inspection and Nondestructive Examination of Welds—Disposition of Defective Welds

2.51.1 Remove or repair welds that are found to be unacceptable, as specified in section 2.54 of this Specification.

2.52 Inspection and Nondestructive Examination of Welds—NDE Records

2.52.1 Prepare inspection records showing milepost, the number of girth welds made, the number non-destructively tested, the number rejected, and the disposition of the welds. Provide the inspection records to the Company. Keep these records for the life of the pipeline.

2.53 Standards of Acceptability

2.53.1 Refer to the following Company-applicable NDE procedures, and API 1104, Section 9 for acceptability for production welding:

- *TES-RT-API Radiographic Examination of Welds Specification (US-MEX)* (EDMS no. 4472888)

- *TES-UT-API Ultrasonic Examination of Girth Welds Specification (US-MEX)* (EDMS no. 1001828660)
- *TEP-NDT-VT Visual Examination (CDN-US-MEX)* (EDMS no. 7381161)

2.54 Repair of Welds Containing Defects—General

2.54.1 Qualify separate welding procedures for repair welding in accordance with API 1104. ASME Section IX states that the original WPS may be used for repair welds.

2.54.2 Ensure repair welding of defects in production welds meets the following requirements:

- Approval obtained from the Company Welding Inspector.
- Qualified welders approved by the Company perform welding using an applicable WPS that has been approved by the Company.
- Repair welding recorded on the inspection reports.

2.55 Repair of Welds Containing Defects—Cracks

2.55.1 Crater cracks may be repaired. Do not repair other cracks of any type or size. Remove indications of cracking by cutting out the weld as a pipe cylinder.

2.55.2 For pipeline applications, remove a cylinder containing the crack and install a replacement pup, if required. Ensure the pup is the greater of 3 ft. (914 mm) or one pipe diameter in length.

2.55.3 For fabrication and facility applications involving pipe-to-pipe or pipe-to-component welds, remove the weld and clean the bevels, and then inspect with MT to ensure the defect has been removed. Alternatively, the cut may be a minimum of 1 in. (25.4 mm) from the edge of the weld. The joint may then be re-welded.

2.56 Repair of Welds Containing Defects—Removal of Defects Other Than Cracks

2.56.1 Except as permitted below, remove defects in welds by grinding.

2.56.2 Defects in welds may be removed by air carbon arc gouging when all of the following requirements are met:

- Ensure wall thickness exceeds 0.375 in. (9.5 mm).
- Preheat a 1 ft. (305 mm) wide area centered around the defective weld metal to a minimum of 125°F (50°C) and a maximum 300°F (150°C) before the gouging process begins.
- After gouging and prior to commencement of welding, make gouged surfaces smooth and free of irregularities by grinding a minimum of 1/16 in. (1.6 mm) of material from the bottom and edges of the groove.
- Ensure the cavity complies with bevel requirements indicated in the repair procedure.

- Visually examine the groove preparation to ensure all traces of carburized metal, copper deposits or other extraneous matter have been removed from the groove.
- Obtain approval from the Company prior to commencing repair welding.

2.56.3 Arc burns shall be reported to the Welding Engineering for disposition. Cut out and replace any section of pipe containing arc burns that cannot be repaired in accordance with Company Specification *TEP-WELD-ABR-US Removal of Arc Burns (New and Existing Piping Facilities) (US-MEX)* (EDMS no. 4472941).

2.56.4 For replacement pups, if required, follow the guidelines in section 2.55.2 of this Specification.

2.56.5 Evaluate pinholes as spherical porosity. Steel punching or peening of pinholes are not acceptable repair methods.

2.56.6 Ensure the maximum individual through-wall repair length is no greater than 10% of the circumference of the pipe. Once this area has been repaired, the process may be repeated. If there is any deviation from this, contact Engineering for approval before proceeding.

2.56.7 Completely remove welds when they contain defects with a total length greater than 1/3 the pipe circumference.

2.57 Repair of Welds Containing Defects—Welding Processes and Consumables

2.57.1 Appendix B of this Specification includes the acceptability of welding processes and consumables, and inspection methods for repairing mainline, tie-in and crossing welds in line pipe with SMYS of 60,000 to 70,000 psi. It does not include line pipe with SMYS greater than or equal to 80,000 psi, or branch connection welds.

2.58 Repair of Welds Containing Defects—Preheat for Repair Welding

2.58.1 Preheat the repair area in accordance with the requirements given in Table 2-2 of this Specification, as well as the appropriate approved repair welding procedure.

2.59 Repair of Welds Containing Defects—Start and Stop of Repair Welds

2.59.1 Grind start/stop of repair welds to conform to the contour of the original weld. Stagger start/stop areas for multi-pass welds by at least 0.5 in. (12.7 mm).

2.60 Repair of Welds Containing Defects—Minimum Length of Repair

2.60.1 The minimum length of a repair is 2 in. (50 mm).

2.61 Repair of Welds Containing Defects—Inspection of Repairs

2.61.1 Confirm removal of defects and repair welding using the same inspection method(s) and procedures used to find the original defects.

2.61.2 Assess any imperfection using the applicable standard of in API 1104 Section 9 and applicable Company Specifications.

2.62 Repair of Welds Containing Defects—Further Repair Attempts

2.62.1 Further repair attempts (double repair) are allowed only after the Inspector has reviewed the weld history, has determined why the first repair attempt was not successful, and has discussed this with the repair welder. If the second repair attempt is not successful, the weld shall be cut out.

2.62.2 Document the action to be taken for any further repairs and submit the plan for approval by Welding Engineering.

2.62.3 To complete further repair attempts, use qualified welding procedures that include multiple repairs and a qualified welder.

2.63 Records and Documentation

2.63.1 Submit a Contractor Turnover Package to the Company at completion of the Project that includes, but is not limited to, the following:

- Purchase order number, Project number
- MTRs
- Weld Map and Weld Log, including NDE log
- List of welding procedures, welding consumable documentation, welding parameter reports, and welder identification used for field installation
- NDE reports (i.e., visual inspection records, radiographic inspection reports, and ultrasonic testing records) that identify the procedure method and technique used for the inspection

3 VARIANCES

Any deviation shall follow the TransCanada Management of Change (MOC) Variance Procedure (EDMS no. 7728702). External vendors must contact the TransCanada Project Engineer for variance approval, who in turn will submit the request to the Responsible Engineer.

4 ROLES AND RESPONSIBILITIES

Table 4-1 below outlines the roles and responsibilities required for the use of this Specification.

Table 4-1: Roles and Responsibilities

Role	Responsibilities
Project Manager	The Project Manager is responsible for ensuring: • all required documentation is submitted and approved • all directives from the Welding Engineer and/or Technologist are understood and followed

Role	Responsibilities
Welding Engineer/Technologist	The Welding Engineer/Technologist is responsible for ensuring: • all required information is reviewed, approved and recorded, and documentation is completed • welding memorandum are issued to the project, outlining the required WPSs and engineering specifications • any requests to deviate from the standards and/or specifications are thoroughly reviewed • changes to Specifications are justified
Welding Inspector (internal and external)	The Welding Inspector is responsible for ensuring: • welders have valid certification • welding parameters are within the weld procedure and documented • NDE inspections are carried out • NDE inspection information is recorded and documentation is submitted • all directives from the Welding Engineer and/or Technologist are understood and followed
Welder (internal and external)	The Welder is responsible for ensuring • all reference documentation is up-to-date • welding specifications are understood and followed • all directives from the Welding Engineer and/or Technologist are understood and followed

5 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are detailed below in Table 5-1. Use the latest document revision, unless otherwise approved by TransCanada.

Table 5-1: External and Internal References

Document No.	Title
Legal Requirements	
49 CFR Part 192	Code of Federal Regulations, Title 49 Part 192, Transportation of Natural Gas and Other Gas by Pipeline: Minimum Federal Safety Standard
49 CFR Part 195	Code of Federal Regulations, Title 49 Part 195, Transportation of Hazardous Liquids by Pipeline: Minimum Federal Safety Standard
NOM-007-SECRE-2010	Transport of Natural Gas

Document No.	Title
Industry Codes and Standards	
API 1104	American Petroleum Institute (API) Welding of Pipelines and Related Facilities
ASME Section IX	American Society of Mechanical Engineers (ASME) BPVC Section IX - Welding, Brazing, and Fusing Qualifications
ASME B31.4	ASME Pipeline Transportation Systems for Liquids and Slurries
ASME B31.8	ASME Gas Transmission and Distribution Piping Systems
ASTM A370	American Society for Testing and Materials (ASTM) Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM E18	Standard Test Methods for Rockwell Hardness of Metallic Materials
ASTM E23	Test Methods for Notched Bar Impact Testing of Metallic Materials
ASTM E384	Standard Test Method for Knoop and Vickers Hardness of Materials
AWS A5.1	American Welding Society (AWS) Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
AWS A5.4	Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding
AWS A5.5	Specification for Low Alloy Steel Electrodes for Shielded Metal Arc Welding
AWS A5.18	Specification for Carbon Steel Filler Metals for Gas Shielded Arc Welding
CSA 245.1	Steel Pipe
Internal References – Documents Referenced by this Specification	
EDMS No. 7076183	TED-MATL-FRAC Materials Fracture Control Plan (CDN-US-MEX)
EDMS No. 4470567	TEF-WELD-QUAL-US Welder Qualification Form - API 1104
EDMS No. 8275922	TEF-WELD-TIE-IN Tie-in Weld In-Process Examination Form (CDN-US-MEX)
EDMS No. 5695478	TEP-MECH-TRAN-US Selection of Transition Pieces and Joining Methods
EDMS No. 7381161	TEP-NDT-VT Visual Examination (CDN-US-MEX)
EDMS No. 4472941	TEP-WELD-ABR-US Removal of Arc Burns (New and Existing Piping Facilities) (US-MEX)
EDMS No. 7169231	TEP-WELD-QUAL-MECH Qualification Procedure for Mechanized Welding Procedure Specifications (CDN-US-MEX)
EDMS No. 8816242	TEP-WELD-SC Storage and Control of Welding Consumables
EDMS No. 6717380	*TES-WL-APIIS-GL Welding on In-Service Pipelines Specification (US-MEX)*

Document No.	Title
EDMS No. 4472888	TES-RT-API (TES-NDT-RT-US) Radiographic Examination of Welds Specification (US-MEX)
EDMS No. 1001828660	TES-UT-API Ultrasonic Examination of Girth Welds Specification (US-MEX)
EDMS No. 1001828218	TES-WELD-API Welding of Pipelines and Facilities Specification (US-MEX)
EDMS No. 1004847597	TES-WL-INSP-G Minimum Weld Inspection Requirements for Small Diameter, Low Percent SMYS Piping Specification (US)
EDMS No. 1004847508	TES-WL-INSPQ-G Welding Inspector Qualification for Operations and Maintenance Related Work Specification (US)

6 DOCUMENTATION AND RECORDKEEPING

Due to the broad range of data types that may be required in support of this Specification, there are a number of repositories that may need to be utilized for documentation purposes. A summary of key data repositories appears in Table 6-1.

Table 6-1: Documentation Requirements

Documentation Description	Repository / Link
Bid Documents Package: • All required specifications, drawings, timelines, materials, etc. for Contractor to bid on project and complete work.	
Turnover Package: • Welder qualifications, weld combustibles, pipe information, test reports etc. All information gathered and recorded by the Contractor during the duration of the project.	

7 DOCUMENT HISTORY

Rev.		
01	**Description**	**Effective Date**
	Revised document to integrate CPG welding program.	2017-May-17
	Rationale Statement	**Responsible Engineer**
	This document was revised to address the following requirements:	Simon Hsu, P.E

Rev.		
	• integration of CPG and TransCanada welding programs • CPG Welding Manual - 290.01.05 • CPG Welding Procedure Index - 290.001.004 • Default In-Service Welding Plan - Standard (non-STOPPLE) Application - 290.01.02 • Default In-Service Welding Plan - STOPPLE or Pressure Tee Fitting - 290.01.01 • In-Service Welding - 290.01.06	
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to combine the best practices of both legacy organizations during the integration of CPG and TransCanada.	Simon Hsu, P.E
00	**Description**	**Effective Date**
	Revised document developed as part of the Centre Of Excellence project.	2016-Nov-01
	Rationale Statement	**Responsible Engineer**
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Simon Hsu, P.E
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation for the Engineering group and clarify the language for readers.	Simon Hsu, P.E

8 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
N/A	

9 APPROVALS

APPROVALS	
Originator: Trent Bertholet, Sr. Welding Technologist Welding and Materials Engineering	Signature: [signature] Date: May 17, 2017
Reviewer: Salvatore Delisi, Sr. Welding Technologist Welding and Materials Engineering	Signature: [signature] Date: 2017-May-17
Reviewer: David Adler, Welding Engineer USGO Engineer	Signature: [signature] Date: 5-17-2017
Responsible Engineer: Simon Hsu, P.E. Welding and Materials Engineering	Signature: [signature] Date: May 17, 2017
Management Endorsement: James Ferguson, Manager Welding and Materials Engineering	Signature: [signature] Date: May 17, 2017

APPENDIX A API 1104 MULTIPLE QUALIFICATIONS OF WELDERS

A-1 PURPOSE

This describes the steps used to multiple qualify welders in accordance with API 1104 for Company projects.

TransCanada does not accept either AWS D1.1 or ASME IX welder certifications for welding with procedures qualified under API 1104 Code.

A-2 GENERAL REQUIREMENTS

Perform welder qualification in accordance with the applicable requirements of:

- 49 CFR 192, Subpart E for gas pipelines
- 49 CFR 195 Subpart D for liquid pipelines
- API 1104
- any amendment, supplement or errata issued by the United States Department of Transportation (DOT) and the American Petroleum Institute

Each welder that successfully completes the four welds described below (Test 1a, 1b, 2a and 2b) is considered a fully multiple-qualified welder for Company projects.

A-2-1 WELDING INSPECTION PERSONNEL

All testing is witnessed, visually accepted and documented by a Certified Welding Inspector (CWI) with a current certification issued through the American Welding Society (AWS) or a Company employee deemed qualified through documented experience (i.e., resume, training records) by Construction Management Services or Technical Training.

Welding inspection personnel are qualified by experience and training for the specified inspection task they perform. Their qualifications are acceptable to and retained by the Company. Documentation includes, but is not limited to the following:

- education and experience, a resume is preferred
- training records
- results of any qualification examinations

A-3 DOCUMENTATION

Take parameters during testing and document the parameters on *TEF-WELD-QUAL-US Welder Qualification Form - API 1104* (EDMS no. 4470567).

A-3-1 WELDING PRE-TEST REVIEW WITH WELDER

- On the Cellulosic (6010/8010) Tests #1 & #1a, 1/8 in. (32 mm) consumables are not permitted on the Hot, Fill or Cap passes.
- Prior to the test commencing, the inspector will check the fit up (clean bevel, proper land, spacing and tacks).

- Cap pass on both butt welds shall be a single puddle cap. The branch welds shall have a two-pass strip cap.

A-3-2 TEST #1

- Cellulose (E6010/E8010) Multiple Qualification Test
- Pipe is NPS 12 (12.750 in. OD) with a wall thickness of 0.250 in. or 0.375 in.
- Pipe grade is not an essential variable for welder testing

Test 1a—The welder first makes a butt weld in the fixed 6G position with the axis of the pipe inclined from the horizontal plane at an angle not exceeding 45°.

- Complete butt weld using WPS API-0-GW-01.
- Validate qualification by:
  - visual examination in accordance with API 1104, Section 6.4
  - destructive testing in accordance with API 1104, Section 6.5
- Two root bends and four nick breaks.

Test 1b—The welder lays out, cuts, fits and welds a full-size, branch-on-pipe connection in the fixed overhead position. Cut a full-size hole in the run. Make the weld with the run pipe axis in the horizontal position, and the branch pipe axis extending vertically downward from the run.

- Complete branch weld using WPS API-0-MQ-11.
- Validate qualification by:
  - visual examination in accordance with API 1104, Section 6.4
  - destructive testing in accordance with API 1104, Section 6.5
- Four nick breaks.

A-3-3 TEST #2

- Cellulose/low-hydrogen (E6010/E8010/E8018) Multiple Qualification Test.
- Pipe is NPS 12 (12.750 in. OD) with a wall thickness of 0.250 in. or 0.375 in.
- Pipe grade is not an essential variable for welder testing.

Test 2a—The welder first makes a butt weld in the fixed 6G position with the axis of the pipe inclined from the horizontal plane at an angle not exceeding 45°.

- Complete butt weld using WPS API-08-GW-02.
- Qualification is validated by:
  - visual Examination in accordance with API 1104, Section 6.4
  - destructive testing in accordance with API 1104, Section 6.5

- Two root bends and four nick breaks.

Test 2b—The welder lays out, cuts, fits and welds a full-size, branch-on-pipe connection in the fixed overhead position. Cut a full-size hole in the run. Make the weld with the run pipe axis in the horizontal position, and the branch pipe axis extending vertically downward from the run.

- Complete branch weld using WPS API-08-MQ-12.
- Validate qualification by:
    - visual examination in accordance with API 1104, Section 6.4
    - destructive testing in accordance with API 1104, Section 6.5
- Four nick breaks.

A-4 NOTES

Test pipe remains fully fixed during welder qualification. Do not move, rotate or otherwise manipulate test pipe from its original position during welder qualification.

All qualification welds (butt and branch) shall be complete (groove and/or fillet entirely filled). Partially completed welds presented for visual or destructive testing are cause to cease further testing.

For the butt weld tests, nick breaks should be substituted for the requisite number of tensile specimens.

Refer to API 1104, Figure 11 for location to remove branch weld destructive test specimens.

Refer to API 1104, Figure 12 for location to remove butt weld destructive test specimens.

A welder who has successfully completed all above weld qualification tests is qualified to weld in all positions, on all wall thicknesses, joint designs, and pipe diameters using all cellulosic or combination-cellulosic and low-hydrogen electrodes, as appropriate.

A-5 WELDER SIX-MONTH RENEWAL TEST

Requalify welders at intervals not to exceed six calendar months.

Perform renewal via radiography by completing a butt weld on NPS 2 or greater piping using either WPS API-0-GW-01 or API-08-GW-02.

Clearly indicate the welder's first name, last name and welder ID on the radiographic inspection report. Submit the report and renewal form *TEF-WELD-QUAL-US Welder Qualification Form - API 1104* (EDMS no. 4470567).

Radiographic inspection reports that do not identify the welder are not be accepted.

Ensure renewal tests are witnessed and documented by an AWS Certified Welding Inspector or a Company employee deemed qualified by Construction Management Services or a representative from the Technical Training group.

Welders who fail to maintain active certifications at maximum six-month intervals are deemed unqualified and must qualify as a new welder taking both API 1104 multiple qualification tests.

APPENDIX B MAINLINE CONSTRUCTION WELDING PROCESSES—SELECTION OF WELDING PROCEDURES FOR PIPE WITH SMYS OF 60,000 TO 70,000 PSI

B-1 PURPOSE

The purpose of this Appendix is to communicate the acceptability and availability of various welding process combinations for welding large diameter pipe with a SMYS of 60,000 to 70,000 psi. This Appendix is provided to Contractors bidding for the construction of large diameter pipelines to help them prepare the welding plan.

B-2 SCOPE

This Appendix includes the acceptability of welding processes and consumables, and inspection methods for making and repairing mainline, tie-in, and crossing welds in line pipe with a SMYS of 60,000 to 70,000 psi. It does not include line pipe with a SMYS greater than or equal to 80,000 psi, or branch connection welds.

B-3 PROCEDURE

The welding plan shall be prepared using a limited number of options of acceptable process combinations for each application as given in section B-4 of this Appendix. Section B-4 also indicates which procedures shall be qualified using project material to develop alternate acceptance criteria in accordance with the requirements of API 1104 Appendix A or an acceptable alternative standard.

Process details for each option, such as joint detail and consumables, and inspection methods shall meet the requirements given in B-5.

Acceptable and qualified options for repair welding are listed in B-6.

B-4 PROCESS COMBINATIONS AND ACCEPTABILITY

Appendix Table B-4-1: Process Combinations and Acceptability for Pipe with SMYS of 60,000 to 70,000 psi

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Root Pass	Internal Mechanized GMAW	External Mechanized GMAW			External Cellulosic SMAW (5)		
Hot Pass	External Mechanized GMAW	External Mechanized GMAW	External Mechanized GMAW or FCAW	External Mechanized GMAW or External LHVD SMAW	External LHVD SMAW or External Cellulosic SMAW (2)	External FCAW or External Cellulosic SMAW (2)	External Cellulosic SMAW
Remaining Passes	External Mechanized GMAW	External Mechanized GMAW	External FCAW	External LHVD SMAW	External LHVD SMAW	External FCAW	External Cellulosic SMAW
Mainline Welding	ACCEPTABLE (1)		ACCEPTABLE (4)		ACCEPTABLE (3)		
Crossings (see Contract Document)	ACCEPTABLE (1)		ACCEPTABLE (4)		ACCEPTABLE (3)		
Tie-ins	N/A				ACCEPTABLE (3)		

Notes:

(1) Requires procedure qualification for each project. To develop alternate acceptance criteria, ensure procedure qualification in accordance with the requirements of API 1104, Appendix A for each wall thickness and consumable combination.

(2) Optional cellulosic hot pass.

(3) Qualified procedures may be available from the Company.

(4) Requires procedure development and qualification. Inspection remains to workmanship criteria.

(5) Optional semi-automatic GMAW (controlled-dip transfer) when using FCAW with external gas shielding for remainder of weld.

B-5 WELDING PROCESS DETAILS

Appendix Table B-5-1: Welding Process Details for Pipe with SMYS of 60,000 to 70,000 psi

	Option 1	Option 2	Option 3	Option 4	Option 5
Joint Design	Narrow Gap Bevel	Narrow Gap Bevel with copper back-up	Standard Bevel		
Root Pass Filler Metal & (Shielding Gas)	K Nova or Lincoln SupraMIG ULTRA with 75Ar-25 CO_2 or 85Ar-15 CO_2	K Nova or Lincoln SupraMIG ULTRA with 100 CO_2, 75Ar-25 CO_2 or 85Ar-15 CO_2	E6010 or ER70S-G (4)		
Hot Pass Filler Metal & (Shielding Gas)	K Nova or Lincoln SupraMIG ULTRA with 100 CO_2	K Nova or Lincoln SupraMIG ULTRA With 100 CO_2 or 75Ar-25 CO_2	Bohler BVD 90 or E8010-G/P1 (2)	NR-208H or E8010-G/P1 (2) or E11T1-K3MJ-H4 with 75Ar-25 CO_2	E8010-G/P1
Remaining Passes Filler Metal & (Shielding Gas)	K Nova or Lincoln SupraMIG ULTRA with 100 CO_2, 75Ar-25CO_2 or 85Ar-15CO_2	K Nova or Lincoln SupraMIG ULTRA with 100 CO_2, 75Ar-25 CO_2 or 85Ar-15 CO_2	Bohler BVD 90	NR-208H None Or E11T1-K3MJ-H4 with 75Ar-25 CO_2	E8010-G/P1
Inspection Method	Mechanized Ultrasonic Testing		Radiographic Testing or Mechanized Ultrasonic Testing to workmanship criteria (3)		

Notes:

(1) Optional FCAW hot pass using NR-208H pending qualification.

(2) Optional cellulosic hot pass.

(3) Check Mechanized Ultrasonic Inspection Procedure status with the Company project manager. Ultrasonic Inspection for semi-auto GMAW.

(4) Optional semi-automatic GMAW (controlled-dip transfer) when using FCAW with external gas shielding for remainder of weld.

B-6 REPAIR WELDING PROCEDURES

Appendix Table B-6-1: Repair Welding Procedures for Pipe with SMYS of 60,000 to 70,000 psi

Process	Filler Metal	Preheat / Interpass	Position and Direction	Inspection Method	Qualifications
I General Repair Procedure					
SMAW, SMAW/FCAW or GMAW/FCAW(1)	Root (through-wall repair): E6010 Remaining: E8018-C1/E8018-C3 or Bohler BVD 90* Internal backweld, where applicable: E8018-C1/E8018-C3, or Bohler BVD 90*	250°F Min 450°F Max	Root: Vertical-down Remainder: Vertical-up	• Ultrasonic testing for weld repairs originally called by ultrasonic inspection • Radiographic inspection for weld repairs originally called by radiographic inspection	Qualified procedures may be available from the Company.
II Internal Bead Misfire Rerun (For Option 1)					
Semi-automatic GMAW. Manual SMAW	K Nova or Lincoln SupraMIG ULTRA, Shielding gas: 75Ar-25CO_2 E8018-C1/E8018-C3	250°F Minimum 450°F Maximum	• Vertical-down welding, GMAW • Vertical-up welding, SMAW	Ultrasonic testing, included in mainline inspection	Requires qualification using project pipe and consumables.

Notes:

(1) When using GMAW/Mech. FCAW: Semi-Auto controlled-dip transfer GMAW (ER70S-G) – root (though-wall repair). Semi-Auto FCAW, E111T1-K3MJ-H4, Lincoln NR-208H remaining.

*Bohler BVD 100 subject to prior approval.

APPENDIX C GUIDANCE FOR THE ULTRASONIC TESTING OF WELDS COMPLETED WITH CELLULOSIC CONSUMABLES (ROOT AND HOT PASS) BETWEEN PIPES OF UNEQUAL WALL THICKNESS WITH ONE SIDE HAVING A BACK BEVEL TRANSITION FOR CRACKS

C-1 PURPOSE

This Appendix describes the requirements for the ultrasonic testing of Shielded Metal Arc Welding back bevel transition girth welds for the detection of cracking.

C-2 SCOPE

This Appendix applies only to welds made using the Shielded Metal Arc Welding (SMAW) process. Further, this Appendix applies only to back bevel transition welds completed with cellulosic consumables (root and hot pass) between pipes having an unequal wall thickness. The examination shall be limited to the inspection of cracking only. Other workmanship imperfections are not to be evaluated.

C-3 NDE TECHNICIAN QUALIFICATION REQUIREMENTS

The qualification of NDE Technicians shall be in accordance with Appendix C of *TES-UT-API Ultrasonic Examination of Girth Welds Specification (US-MEX)* (EDMS no. 1001828660).

C-4 ULTRASONIC PROCEDURE

An Ultrasonic Testing procedure shall be established using guidance shown in API 1104 Section 11.4.2.2.

C-5 EQUIPMENT REQUIREMENTS

The equipment used as required by this Appendix shall be in accordance with Appendix C of *TES-UT-API Ultrasonic Examination of Girth Welds Specification (US-MEX)* (EDMS no. 1001828660).

An IIW or similar block is recommended for equipment calibration. Specified reflectors (e.g., drilled holes, flat bottom holes, notches) shall be used to establish primary reference responses of the equipment. Alternative reflector(s) may be used provided that the alternative reflector(s) produces a sensitivity equal to or greater than the specified reflector(s) (e.g., drilled holes in lieu of notches).

C-6 EXAMINATION OF WELDS

C-6-1 BASE METAL EXAMINATION

A compression wave test of the parent material on both sides of the weld (minimum distance of 1.25 times the longest surface skip distance) shall be performed. All interfering partial and full beam reflectors shall be noted (datum location and distance from the weld edge) and recorded on the examination record.

Using a longitudinal wave transducer, adjust the second back-wall echo in the base material to at least 80 % of FSH and examine for laminar or stringer imperfections which may interfere with the transverse wave examination. All significant imperfections shall be recorded and, where practical, the transverse wave examination shall be modified to compensate for their presence. The area to be examined shall cover 100 % of the base metal though which the transverse wave will pass.

C-6-2 MANUAL ULTRASONIC TESTING

Manual ultrasonic weld testing shall be performed at a scanning sensitivity of DAC/TCG reference sensitivity plus 6 dB minimum. All indications that exceed 50% of DAC/TCG screen height shall be evaluated. Evaluation sensitivity for manual ultrasonic weld testing should be DAC/TCG reference sensitivity plus 6 dB with an evaluation level for all indications at 50% of DAC/TCG screen height.

C-6-3 AUTOMATED ULTRASONIC WELD TESTING

Automated ultrasonic weld testing should be performed at a scanning sensitivity of 80% screen height reference sensitivity plus 4 dB when using the pulse-echo technique. Evaluation should be the same as scanning sensitivity. Evaluation level screen height (recording threshold) should be 40% of full screen height using the automated pulse-echo technique. Other automated techniques, reference reflectors, reference, scanning sensitivities, evaluation sensitivities and evaluation levels may be used if demonstrated to be equivalent to the pulse-echo technique for the detection and evaluation of weld imperfections.

C-7 EVALUATION

Indications evaluated as a crack of any size, in any pass, are deemed unacceptable and shall be reported to the Company. The inspection report shall note the crack length and location.

Welder's Name (print)	Welder's ID Stamp (Initials – last 4 digits of SSN)	Project Name

Initial Multiple Qualification	☐	Multiple Qual. Renewal by NDE	☐	Project Number

TEST CONDITIONS

Weld Type	Butt	Branch
Pipe Specification & Grade		
Diameter of Test Pipe		
Wall Thickness		
Fixed Pipe Position		
API Filler Metal Groups (1 - E6010 / 2 - E8010 / 3 - E8018)		
Welding Procedure Specification		

VISUAL ACCEPTABLE ("X")		YES	☐	NO	☐	YES	☐	NO	☐

		QTY	Pass	Fail	QTY	Pass	Fail
Number of Tests Completed Per Weld	Nick						
	Face						
	Root						
	Tensile						
	Side						

6 MONTH EXTENSION OF MULTIPLE QUALIFICATION BASED ON NDE OF BUTT WELD

(NDE Report Must Be Attached to this Form and Identify the Welder)

NDE VENDOR	LEVEL II TECH	WELD ID	NDE REPORT NO.

NDE ACCEPTABLE TO API 1104	☐	YES	☐	NO

Comments

Welding Inspector's Name (Please Print)	Welding Inspector's Signature & CWI Stamp	Date of Test
		Date of Qualification Expiry (Valid 6 Months)

WELD PARAMETER DETAILS						
Welder Name and ID Stamp:						
Welding Procedure:	☐	API-0-GW-01		☐	API-08-GW-02	
Welding Position:	FIXED - 5G			**Preheat:**		
Weld Pass #:	ROOT	HOT	FILL	CAP		
Electrode Diameter:						
Electrode Type:						
Measured Weld Current Range:						
Measured Weld Voltage Range:						
Measured Travel Speed Range:						
Direction of Travel:						
Welding Procedure:	☐	API-0-MQ-11		☐	API-08-MQ-12	
Welding Position:	FIXED – BRANCH FACING DOWN			**Preheat:**		
Weld Pass #:	ROOT	HOT	FILL	CAP		
Electrode Diameter:						
Electrode Type:						
Measured Weld Current Range:						
Measured Weld Voltage Range:						
Measured Travel Speed Range:						
Direction of Travel:						

PURPOSE

This Specification outlines the engineering and design requirements for the successful completion of a pressure test on new construction and system additions.

SCOPE / APPLICABILITY

This Specification applies to the following pipelines and facilities constructed for and/or operated by the Company in the United States (U.S.):

- new construction and additions to existing systems of both natural gas and natural gas liquid pipelines and hazardous liquid pipelines
- meter, regulator, compressor, pump, and delivery station piping
- terminal piping and service lines

This Specification applies to the following pipelines and facilities constructed for and/or operated by the Company in Mexico:

- new construction and additions to existing natural gas pipelines
- meter, regulator, compressor station piping, and service lines

This Specification does not apply to:

- pressure testing of high vapor pressure (HVP) pipelines (except natural gas liquid), and CO2 pipelines
- energy facilities (power plants)
- integrity testing of existing pipelines; refer to *TES-HYDRO-INT-US Hydrostatic Test Specification for Integrity Testing of Existing Pipelines (US)* (EDMS No. 6058463)
- LNG process piping testing; refer to *CPG: Pressure Test LNG Process Piping Plan (US) Plan 310.34.02*
- tank pressure testing; refer to *TES-TANK-HYDRO Tank Hydrotest Specification (CDN-US-MEX) (EDMS No. 8040864)*

For pressure testing requirements of pipelines and piping systems that are not within the scope of this Specification, refer to the applicable sections of *CFR 49 Part 192,195 and 193, NOM-007-SECRE-2010,* other company standards, specifications and applicable industry codes or consult with the Responsible Engineer.

Within this Specification, TransCanada is referred to as the Company.

Within this Specification, the following terms and definitions apply for requirements:

- Shall—expresses a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard. Shall is not a recommendation but a requirement.

- Should—expresses a strong preference, recommendation or that which is advised, but not required.
- Must—denotes a requirement of the Company, for which no deviation or variance would be granted.
- May—expresses an option or that which is permissible within the limits of the standard.
- Consider—assumes that a competent person will evaluate options to fulfill the intent of the requirement and make a documented decision supported by evidence to ensure protection of people, equipment and the environment by achieving the appropriate level of functional integrity.

This document shall be reviewed once per calendar year, not to exceed 15 months.

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1 GLOSSARY

ANSI

American National Standards Institute

API

American Petroleum Institute

ASME

American Society of Mechanical Engineers

Certificate of Compliance/Certificate of Conformance (CofC)

A quality assurance document generally received from valve manufacturers (for material items 2" in diameter or smaller) certifying the item was produced in compliance with international standards organization standards (ANSI, ASME, etc.).

CFR

Code of Federal Regulations

Design pressure (internal design pressure)

The maximum internal pressure limit based on the material of the pipeline segment. Design pressure is greater than or equal to the maximum allowable operating pressure (MAOP) of natural and other gas pipelines, or the maximum operating pressure (MOP) in the case of hazardous liquids pipelines.

Double deviation (0.2% deviation)

The pressure at which the number of pump strokes (measured volume) per increment of pressure rise becomes twice the number of pump strokes (measured volume) per increment of pressure rise that was required during the straight-line part of the pressure-volume plot before any deviation occurs.

Gas

Natural gas, flammable gas, or gas which is toxic or corrosive.

Hazardous liquid

Petroleum, petroleum products or anhydrous ammonia

HDD

Horizontal Directional Drill

High consequence area (HCA)

Refer to 49 *CFR* part 192.903, 192.905 and part 195.450 for the definition of High Consequence Areas.

High vapor pressure (HVP)

A pipeline system conveying hydrocarbons or hydrocarbon mixtures in the liquid or quasi-liquid state with a vapour pressure greater than 110 kPa absolute at 38°C, as determined using the Reid method (see *ASTM D323*).

Leak test

A procedure used in conjunction with testing to detect the existence or evidence of leaks in the pipeline by means of visual or analytical processes.

For piping that is entirely visible during the test, the leak test will consist of observation of the piping while under pressure to check for visible or audible evidence of a leak. For piping below ground or otherwise not visible, the leak test will consist of an approved procedure whereby pressure variations during Strength Testing are accounted for, taking into account the effects of temperature and pressure on the test medium and pipe. Pressure loss that cannot be satisfactorily attributed to these factors, measurement error or other factors peculiar to the situation will be considered evidence of a leak.

Maximum allowable operating pressure (MAOP)

The maximum pressure at which a pipeline or segment of a pipeline may be operated under *49 CFR Part 192 Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards*. Maximum Permissible Operating Pressure (MPOP) may be applied in Mexico when used in according to NOM-007-SECRE-2010.

Maximum operating pressure (MOP)

The maximum pressure at which a pipeline or segment of a pipeline may be normally operated under *49 CFR Part 195 Transportation of Hazardous Liquids by Pipeline.*

Maximum test pressure (MTP)

The maximum internal fluid pressure permitted for testing, for the materials and for Part 192 and 195 facilities, class location involved. The Company's limit is 110 percent SMYS of the weakest segment of pipe or pipe-type component or the pressure that produces double deviation, or pressure rating of non-pipe components, whichever is lower.

MTR

A Mill Test Report, Material Test Report, Mill Test Certificate or equivalent is a quality assurance document used in the metals industry that certifies a material's chemical and physical properties. It also confirms that the material was produced in compliance with international standards organization (e.g., ANSI, ASME, etc.)

NGL

Natural Gas Liquids

Regulatory Commission of Energy

Mexican regulating authority

P-V plot

A pressure vs. volume plot. Also known as a yield plot.

PHMSA

Pipeline and Hazardous Materials Safety Administration of US Department of Transportation (DOT)

Post-test tie-ins (non-pressure tested field welds)

Welds completed after the pressure test is conducted. The welds required to install the tested item/assembly in its final location.

Prefabricated / fabricated assembly

An arrangement of piping that is joined together prior to installation in the pipeline system. Fabricated assemblies are defined as the joining of fittings, valves, flanges and other components.

Pressure test failure

A pipeline rupture or leak that occurs during a pressure test.

Service line

A distribution line that transports gas from a common source of supply to an individual customer, to two adjacent or adjoining residential or small commercial customers, or to multiple residential or small commercial customers served through a meter header or manifold. A service line ends at the outlet of the customer meter or at the connection to a customer's piping, whichever is further downstream, or at the connection to customer piping if there is no meter.

Short section

Pipeline assemblies, piping spools, fabricated assemblies, and lengths of pipe (typically less than 120 ft) which are 100 percent visible.

SMYS

Specified Minimum Yield Strength of a material. Minimum Resistance Transfer (MRT) is equivalent to the SMYS term and may be used in Mexico in according to NOM-007-SECRE-2010.

Start pressure (strength test)

The minimum strength test pressure.

Strength test

The test designed to establish a pipeline's operating pressure limit as required by code or regulation. It involves the pressurization of piping to a minimum predetermined stress level or pressure and maintaining this stress level or pressure for a predetermined time interval or hold period.

Test head assembly

The assembly of valves, pipe, cradle grating (if applicable), fittings, etc. that together form the temporary facility used for the pressure testing piping. Test head assemblies are used on longer pipeline sections. A test head assembly is normally provided with a separate (NPS 4 to NPS8) fill valve along with throttling valves (NPS 2). The distance between the fill valves and throttling valves shall be sufficient for at least two pigs to fit in the assembly. The pig length is generally less than 1.5 times the test head nominal pipe diameter.

Test cap assembly

The assembly of valves, pipe, fittings, etc. that together form the temporary facility used for the pressure testing piping. Test cap assemblies are used on short section of pipelines and facility piping. A test cap assembly is provided with throttling valves (NPS 2) that are also used for filling the test sections. The distance between the fill/throttling valves shall be sufficient for one pig to fit in the assembly. The pig length is generally less than 1.5 times the test head nominal pipe diameter.

Test end cap

An end cap fitting that can only be used once for pressure testing

2 GENERAL

2.1 General Requirement

2.1.1 A pipeline is generally pressure-tested above its operating pressure in place, after installation, but before it is put into service. The pressure testing must comply with the following, as well as with any additional requirements indicated within project specific special permits if applicable:

- U.S.: *49 CFR Part 192 Transportation of Natural and Other Gas by Pipeline, Minimum Federal Safety Standards*, including:
  - Subpart G – General Construction Requirements for Transmission Lines and Mains
  - Subpart J –Test Requirements
  - Subpart L – Operations
- U.S.: *49 CFR Part 195 Transportation of Hazardous Liquids by Pipeline*, including:
  - Subpart D – Construction
  - Subpart E – Pressure Testing
- Mexico: *NOM-007-SECRE-2010: Transport of Natural Gas*

3 SAFETY REQUIREMENTS

3.1 General

3.1.1 All field work shall conform to the site-specific safety plan.

3.1.2 The site-specific safety plan shall address the following:

- location of test sections relative to HCA in the case of uncontrolled depressurization, including property, operating facilities, public spaces, and testing personnel
- test failure modes
- pressure level
- safe access, egress, and escape from test head and pressure recording equipment locations

3.1.3 All work shall conform to relevant Occupational Safety and Health regulations.

4 ENVIRONMENTAL CONSIDERATIONS

4.1.1 Project personnel shall contact the appropriate Company's environmental group for environmental requirements:

- For natural gas pipelines and facilities, the project team shall engage the Environmental Planning and Permitting team to develop site-specific plans for water discharge (and withdrawal if required).
- For hazardous liquid pipelines, the project team shall engage the Liquids Environmental Services team to develop site-specific plans for water discharge (and withdrawal if required).

4.1.2 Project personnel shall contact the Company's Environmental Advisor for considerations and/or requirements.

5 BURIED PIPELINE PRESSURE TEST REQUIREMENTS

5.1 General

5.1.1 Test pressures and durations shall be provided on the drawings, test plan and/or in the project-specific documents.

5.1.2 Relocated, replaced and/or otherwise changed pipe and assemblies must be pressure tested to substantiate the MAOP/MOP in accordance with CFR 192.503 and 195.302 before returning to service.

5.1.3 The test pressure shall not exceed the specified maximum test pressure (MTP) and shall not drop below the prescribed minimum test pressure.

5.1.4 A pressure test conducted between the maximum and minimum test pressure limits and for the correct test duration but without consideration of the pressure versus temperature (i.e. ambient, test medium and/or ground temperatures) data is not automatically an acceptable test.

5.2 Test Medium

The following requirements apply to natural gas pipelines:

5.2.1 Water is the preferred pressure test medium for steel pipe. See 5.2.2 through 5.2.8 for conditions for use of other mediums.

5.2.2 Site-specific approval shall be acquired from the Company's Design Engineer for natural gas as a test medium.

5.2.3 Site-specific approval shall be acquired from the Company's Design Engineer for air or inert gas as a test medium for pipelines operating at a hoop stress of 30 percent or more of SMYS.

5.2.4 Site-specific approval shall be acquired from the Company's Design Engineer to test with air or inert gas as a test medium for pipe sizes NPS 10 and larger.

5.2.5 Air is the preferred medium for testing polyethylene plastic pipelines. Inert gas or natural gas may also be used. The use of water for testing polyethylene pipe is discouraged.

5.2.6 Typical conditions for the use of air, inert or natural gas as a test mediums are as follows:

- The ambient temperature is expected to be less than 32°F.
- Water of appropriate quality is not available in sufficient quantity.
- The piping configuration will make liquid removal difficult or impractical.
- The pipeline has large elevation differences needing excessive number of test sections for hydrostatic test.

5.2.7 CO2, HVP liquids, or fluids containing H2S shall not be used as pressure test medium.

5.2.8 For **hazardous liquid service pipelines**, air or inert gas may be used as the test medium in low-stress ($\leq$ 20 percent of SMYS) hazardous liquid pipelines, in accordance with *49 CFR Part 195.306 (d)*.

5.3 Pre-Installation One-Hour Leak Test

5.3.1 All HDD pipe, concrete-coated pipe, and other pipe specified in the contract shall be pre-tested.

5.3.2 The pre-test pressure shall be equal to or greater than the test pressure required for the Mainline test that will be conducted for the intended MAOP/MOP for a minimum of one hour or until the piping is determined to be leak free, whichever is longer, before the installation of HDD pipe, concrete-coated pipe, or other pipe specified in the contract. Once in place, the pre-tested carrier pipe shall be tested as part of the post installation mainline test.

5.3.3 Non-HDD bores for high pressure gas and hazardous liquid pipeline crossings which include, but are not limited to, road, railroad, river, stream, or creek crossings may be pre-tested, as specified in the contract, permit and/or the crossing agreement. Once in place, the pre-tested pipe shall be tested as part of the post-installation mainline test.

5.4 Natural and Other Gas Pipeline Test Pressure and Duration

5.4.1 Operation at a Hoop Stress of 30 percent or More of SMYS

5.4.1.1 Test Pressure Limits

1. The pressure test should be performed at the highest possible test pressure commensurate with the design pressure to qualify for operation in the highest-class location area possible.
2. At any point in the test section, pressure shall not produce hoop stress that exceeds the lesser of 0.2 percent deviation on a P-V plot

or 110 percent of the pipe's SMYS. Concurrently, the maximum working pressure of the test heads used shall not be exceeded.

3. The strength test shall start at a pressure between the minimum and maximum limits. Refer to Table 5-1 below for minimum and maximum pressure test pressure limits based on requirements in 49 CFR 192.503 and 192.619, and the Company requirements for natural gas pipelines.

Table 5-1: Pressure Test Pressure Limits

Application	Minimum Test Pressure Limit Using Water	Maximum Test Pressure Limit for Using Water	Maximum Hoop Stress Limitation for Using Air or Inert Gas	Maximum Hoop Stress Limitation for Using Natural Gas
Pipeline in Class 1 Location	1.25 × MAOP	Lesser of 0.2% deviation on a PV-plot or 110% SMYS	80% SMYS[1]	80% SMYS
Pipeline in Class 2 Location	1.25 × MAOP		75% SMYS[1]	30% SMYS
Pipeline in Class 3 Location[2]	1.50 × MAOP		50% SMYS	30% SMYS
Pipeline in Class 4 Location[2]	1.50 × MAOP		40% SMYS	30% SMYS
Meter and Regulator Station	1.50 × MAOP		See Class Location for Limit	See Class Location for Limit
Compressor Station	1.50 × MAOP		See Class Location for Limit	See Class Location for Limit

[1] See *49 CFR Part 192.505 (a)* for additional provisions.

[2] For Mexico; pipeline must be hydrostatically tested in accordance with *NOM-007-SECRE-2010.*

4. Refer to Table 5-2 for minimum and maximum pressure test pressure limits based on requirements of *49 CFR 192.620, Alternative Maximum Allowable Operating Pressure (MAOP)*.

Table 5-2: Pressure Test Pressure Limits – Alternative MAOP

Application	Alternative Design Factor	Minimum Test Pressure Limit for Using Water	Maximum Test Pressure Limit for Using Water
Pipeline in Class 1 Location	0.8	1.25 × MAOP	Lesser of 0.2% deviation on a P-V plot and 110% SMYS
Pipeline in Class 2 Location	0.67	1.50 × MAOP	
Pipeline in Class 3 Location	0.56	1.50 × MAOP	

5.4.1.2 Pressure Test Duration

1. The duration of the strength test shall not be less than eight continuous hours above the minimum test pressure. For short-section and prefabricated assemblies, refer to section 6.3.

5.4.1.3 Leak Test

1. For tests of pipelines operating over 30 percent SMYS, 49 CFR Part 192 does not require a separate leak test; therefore, it may be conducted concurrently with the strength test.
2. For pneumatic tests carried out in Mexico, test duration shall be 24 hours in accordance with NOM-007-SECRE-2010.

5.4.2 Operation at a Hoop Stress Less Than 30% of SMYS and at or Above 100 psig (689 kPa)

5.4.2.1 Except for service lines and plastic pipelines, each segment of a pipeline that is to be operated at a hoop stress less than 30 percent of SMYS and at or above 100 psig (689 kPa) must be tested in accordance with 49 CFR Part 192.507:

1. The Company must use a test procedure that will ensure discovery of all potentially hazardous leaks in the segment being tested.
2. If, during the test, the segment is to be stressed to 20 percent or more of SMYS and natural gas, inert gas, or air is the test medium.
   - A leak test must be made at a pressure between 100 psig (689 kPa) gauge and the pressure required to produce a hoop stress of 20 percent of SMYS.
   - The line must be walked to check for leaks while the hoop stress is held at approximately 20 percent of SMYS.
3. The pressure must be maintained at or above the test pressure for at least one hour.

5.4.3 Operation at Pressure Less than 100 psig (689 kPa) for Steel Pipelines

5.4.3.1 Except for service lines and plastic pipelines, each segment of a pipeline that is to be operated below 100 psig (689 kPa) must be leak tested in accordance with 49 CFR Part 192.509:

1. The Company must use a test procedure that will ensure discovery of all potentially hazardous leaks in the segment being tested.
2. Each main that is to be operated at less than 1 psig (6.9 kPa) must be tested to at least 10 psig (69 kPa) and each main to be operated at or above 1 psig (6.9 kPa) must be tested to at least 90 psig (621 kPa).

5.4.3.2 In addition, pipelines intended for operation below 100 psig (689 kPa) shall be successfully leak tested to at least 150 percent MAOP or 90 psig (621 kPa), whichever is greater, for a minimum duration of one hour using water, air, or inert gas as a test medium.

5.4.4 Steel Service Pipelines

5.4.4.1 Steel service pipelines shall be successfully tested in accordance with 49 CFR Part 192.511 Test Requirements for Services Lines as follows:

1. Each segment of a service line (other than plastic) must be leak tested in accordance with this section before being placed in service. If feasible, the service line connection to the main must be included in the test; if not feasible, it must be given a leakage test at the operating pressure when placed in service.
2. Each segment of a service line (other than plastic) intended to be operated at a pressure of at least 1 psig (6.9 kPa) but not more than 40 psig (276 kPa) must be given a leak test at a pressure of not less than 50 psig (345 kPa).
3. Each segment of a service line (other than plastic) intended to be operated at pressures of more than 40 psig (276 kPa) must be tested to at least 90 psig. (621 kPa), except that each segment of a steel service line stressed to 20 percent or more of SMYS must be tested in accordance with 49 CFR Part 192.507.

5.4.4.2 Test shall be conducted for a minimum of one hour.

5.4.5 Polyethylene Plastic Pipelines

5.4.5.1 Polyethylene plastic pipelines shall be successfully tested in accordance with 49 CFR Part 192.513 at a minimum:

1. Each segment of a plastic pipeline must be tested in accordance with this section.
2. The test procedure must insure discovery of all potentially hazardous leaks in the segment being tested. See section 5.4.5.3 for the Company's required minimum duration.
3. See section 5.4.5.2 for Company required minimum test pressures. These exceed the requirements of 49 CFR 192.513 which reads as follows:

   The test pressure must be at least 150 percent of the maximum operating pressure or 50 psig (345 kPa), whichever is greater. However, the maximum test pressure may not be more than three times the pressure determined under 49 CFR Part 192.121, at a temperature not less than the pipe temperature during the test.
4. During the test, the temperature of thermoplastic material may not be more than 100°F (38°C), or the temperature at which the material's long-term hydrostatic strength has been determined under the listed specification, whichever is greater.

5.4.5.2 In addition, the test pressure must be at least 150 percent of the MAOP or 90 psig (620 kPa), whichever is greater. However, the MTP shall not be more than three times the pressure determined under 49 CFR Part

192.121, at a temperature not less than the pipe temperature during the test.

5.4.5.3 Test shall be conducted for a minimum of one hour.

5.5 Hazardous Liquid Pipeline Test Pressure and Duration

5.5.1 A hazardous liquid pipeline pressure test shall consist of a strength test and a leak test in accordance with *49 CFR Part 195.304*.

5.5.2 In accordance with *49 CFR Part 195.304*: "The test pressure must be maintained at a pressure equal to or greater than 125 percent of the MOP for four continuous hours. A concurrent leak test shall be conducted if the pipeline is visible. In the case of a pipeline that is not visually inspected for leakage during the test, the test pressure shall be maintained for at least an additional four continuous hours at a pressure equal to or greater than 110 percent of the MOP."

5.5.3 The MTP for a section shall be the lesser of 0.2 percent deviation on a P-V plot or 110 percent of the pipe's SMYS.

5.6 P-V Plotting

5.6.1 P-V plotting shall be required for hydrotesting at a pressure which will produce a hoop stress equal to or greater than 100 percent SMYS of the pipe.

5.6.2 If P-V plots cannot be produced accurately for short test sections, the pipe used for the test section shall be designed such that the MTP will produce a hoop stress less than 100 percent SMYS of the pipe.

5.7 Testing of Tie-Ins

The following requirements apply to non-pressure tested tie-in welds for natural and other gas pipelines:

5.7.1 The regulations and codes of construction for pipelines and pipeline facilities in the U.S. and Mexico recognize that not all welds can be pressure tested. Appendix A is non-mandatory and provides examples for guidance only. Selection and justification of locations for non-pressure tested welds is project specific and subject to project specific conditions and risks.

5.7.2 The rationale used to determine the location and number of non-pressure tested welds left in a pipeline system shall be documented.

5.7.3 Also refer to the following sections for scenarios in which post-test tie-in welds (non-pressure tested field welds) may be acceptable in an installed pressure piping system. Prior written approval is needed from the Company Integrity and/or Reliability Engineering Manager.

5.7.3.1 Tie-ins to existing facilities – Non-pressure tested welds required to make tie-ins of short lengths of pipe or new piping assemblies to existing facilities are acceptable. Re-testing of previously in-service components in the test section shall be avoided. Refer to Appendix A for examples of tie-ins to existing facilities to assist the Company's Design Engineer in minimizing the number of non-pressure-tested welds.

5.7.3.2 Tie-ins to previously pressure tested pipelines – This section does not preclude the cutting in of pipeline assemblies following a pressure test of a new pipeline. Refer to Appendix A for examples of tie-ins to previously tested facilities to assist the Company's Design Engineer in minimizing the number of non-pressure tested welds.

5.7.3.3 Positioning of test caps or test heads – Where field pressure testing is performed, space is required to accommodate the required test heads or test caps. Following the test, the head or cap is removed and may be replaced with pre-tested pipe or a pre-tested spool piece to make the final connections to existing infrastructure or other parts of the new facility, resulting in non-pressure tested field welds.

5.7.3.4 Stress free tie-ins and weld alignment – Alignment of piping to meet the requirements of the design code to produce stress free welds can result in the need for non-pressure-tested welds to allow sufficient adjustability to achieve compliant alignment. Where the specified welding alignment cannot be achieved without placing excessive external forces on the pipe, additional non-pressure tested welds are permitted. Refer to the Company's Welding specification TES-WELD-API Welding of Pipelines and Facilities Specification (US-MEX) *(EDMS No.* 1001828218) or guidance on alignment prior to welding (i.e. clause 2.30.2: "External forces to align pipe shall be kept to a minimum").

Note:

This justification shall be used with care and discretion to account for unknown or unknowable factors that cannot be mitigated by careful planning in the design phase. For documentation of justification for non-pressure tested welds, refer to Appendix B.

5.7.3.5 Non-pressure tested welds are acceptable when testing to eliminate such a weld would create an unsafe condition that cannot be mitigated by other means.

5.7.4 For **hazardous liquid pipelines**, pipe associated with tie-ins must be pressure tested, either with the section to be tied in or separately.

5.7.5 Each non-welded joint (i.e., flanges and threaded joints) must be leak tested at not less than its operating pressure.

6 SHORT SECTION PRESSURE TEST REQUIREMENTS

6.1 General

6.1.1 All pipe and fabricated units installed directly into or connected to an existing pipeline or facility shall be pressure tested before installation.

6.1.2 If a component other than pipe is the only item being replaced or added to a pipeline, a strength test after installation is not required, if the manufacturer of the component certifies that it is tested during manufacturing at the pressure required for the system to which it is being added in accordance with *49 CFR Part 192.503 (e) (1), (2), (3)* and *49 CFR Part 195.305 (b)*

6.1.3 If an ASME pressure vessel (e.g., strainer, filter, heat exchanger, etc.) is the only item being replaced or added to a pipeline; and if it is tested during manufacturing at the pressure and duration required for the system to which it is being added; and the manufacturer provides the documentation; it does not require pressure-testing again.

6.1.4 Equipment or vessels may be tested with the rest of the system if the system test pressure is less than the equipment or vessel Manufacturer's MTP. To test a piece of equipment or vessel above the MTP used by the Manufacturer requires verification from the Manufacturer that the item is capable of holding the proposed pressure with no damage.

6.1.5 For fabricated units and short sections of pipe, for which a post-installation test is impractical, a pre-installation strength test must be conducted by maintaining the pressure at or above the test pressure for at least four hours.

6.1.6 Pipe with a counter bore and taper transition must be shop or field pressure tested, counter bore and taper cannot be done after pressure testing.

6.2 Test Medium

6.2.1 Refer to section 5.2, test medium.

6.3 Natural and Other Gas Pipeline Test Pressure and Duration

6.3.1 Operation at a Hoop Stress of 30% or More of SMYS

6.3.1.1 The short section pressure test shall include a strength test, in accordance with 49 CFR, Part 192, subpart J and the Company requirements.

6.3.1.2 The minimum and maximum test pressure limits listed in Table 5-1 shall be used for short section strength tests. Where applicable, Table 5-2 shall be used for alternative maximum and minimum pressure limits.

6.3.1.3 The duration of the strength test shall not be less than eight continuous hours at or above the minimum test pressure, unless a post-installation test is impractical. In this case, a four-hour pre-installation strength test may be acceptable (see section 5.7 for justification of non-pressure tested tie-in welds).

6.3.1.4 For fully visible piping and assemblies, the leak test may be conducted concurrent with the strength test provided enough time is taken to adequately inspect the short section.

6.3.2 For operation at a hoop stress less than 30 percent of SMYS and at or above 100 psig (689 kPa), refer to section 5.4.2.

6.3.3 For operation at pressure less than 100 psig (689 kPag), refer to section 5.4.3.

6.3.4 For steel service pipelines, refer to section 5.4.4.

6.3.5 For polyethylene plastic pipelines, refer to section 5.4.5.

6.4 Hazardous Liquid Pipeline Test Pressure and Duration

6.4.1 Refer to section 5.5, hazardous liquid pipeline test pressure and duration.

7 PRESSURE TEST REQUIREMENTS FOR AUXILIARY PIPING & TUBING

7.1 Test Pressure and Duration

7.1.1 Auxiliary piping is piping required for direct operation of a station/facility, other than main gas or fuel gas piping (upstream of the first cut DOT regulator). Examples of auxiliary piping may include:

- air systems (B31.1 and B31.3)
- ESD pneumatic air systems (B31.1 and B31.3)
- lube oil system (B31.3)
- cooling water/jacket water systems (B31.1)
- hydraulic oil systems (B31.3)
- glycol systems (B31.1)
- fuel gas piping downstream of first cut DOT regulator (B31.3)
- vent piping (e.g. inlet pipe for silencers or mist eliminators, outlet piping for relief valves, etc.) (code used depends on the service)

7.1.2 Pressure test requirements for various piping systems are outlined in Table 7-1 below:

Table 7-1: Pressure Test Requirements for Auxiliary Piping Systems

Applicable Systems	Test Medium	Pressure Testing Requirements	Test Pressure(s)	Duration
• High Pressure Fire Suppression Piping • Cooling Water Piping • Potable and Fresh Water Lines[1] • Compressed Air Piping (design pressure up to 150 psig (1035 kPa) • Heating System (Water/Glycol Piping)	Service Fluid	All piping at every point within the system shall be subject to an in-service leak test. The test supervisor must be satisfied that any changes in pressure are not the result of leaks before the leak test is concluded.	MAOP/MOP	Not less than 10 minutes and additional time as necessary to conduct an examination for leakage.

Applicable Systems	Test Medium	Pressure Testing Requirements	Test Pressure(s)	Duration
• High Pressure Seal and Hydraulic Oil Piping • Compressed Air Piping (design pressure over 150 psig (1035 kPa) • Low Pressure Lubricating Oil Piping • ESD Air System • Fuel gas piping downstream of first cut DOT regulator	Water	The test pressure shall not exceed the MTP of any component in the system.	150% of Design Pressure and shall not exceed 100% SMYS.	Not less than one hour and additional time as necessary to conduct an examination for leakage.
• High Pressure Seal and Hydraulic Oil Piping • Compressed Air Piping (design pressure over 150 psig (1035 kPa) • Low Pressure Lubricating Oil Piping • ESD Air System • Fuel gas piping downstream of first cut DOT regulator	Inert Gas	The test pressure shall not exceed the MTP of any component in the system.	110% of Design Pressure or min. test pressure plus 50 psig and shall not exceed 90% SMYS.	Not less than one hour, and additional time as necessary to conduct an examination for leakage.
• Seal Oil Piping (External to skid only) • Lube Oil Piping (External to skid only)	Lube Oil	The test pressure shall not exceed the MTP of any component in the system.	150% of Design Pressure and shall not exceed 100% SMYS.	One hour
• Plumbing Vents and Drains[1]	Water		Minimum Test Pressure 2 psig (14 kPag), Maximum Test Pressure 5 psig (35 kPag)	One hour
[1] Refer to applicable plumbing codes for additional testing requirements.				

7.1.3 Most vent piping (e.g., ESD vents, relief valve stacks, etc.) does not require a test. The exception to this is vent piping that could become obstructed (e.g. ice, etc.) such that would retain pressure. If this is anticipated, the piping shall be tested according to this Specification.

7.2 Test Requirements for Tubing

7.2.1 Tubing shall be subjected to a leak test, in accordance with the requirements outlined in Table 7-2, after it has been bent, assembled, and installed in place. All fittings shall be examined visually to ensure the integrity and confirm that proper compression has occurred in the fitting.

7.2.2 Pressure rated tubing NPS 1/2 and smaller does not need to be tested; however, a soap bubble leak test must be done at all connections once the tubing has been installed and put into service.

Table 7-2: Leak Test Requirements for Tubing

Topic	Requirements
Test conditions	• Instrument tubing supplied and installed by Vendors on control valves and all other instruments shall be leak tested on-site by the Contractor. • Where practical, the tubing shall be isolated from the rest of system. • All fittings shall be checked for leaks using gas and "Snoop" fluid or soap solution and brushes.
Leak test pressure	• The leak test pressure shall be the maximum system pressure available at the time of the test. • The pressure shall be increased gradually in steps providing sufficient time to allow the tubing to equalize strains during test and to check for leaks.
Leak test duration	• The duration of the leak test shall be maintained for a sufficient time, not less than ten (10) minutes.
Results	• The test supervisor must be satisfied that any changes in pressure are not the result of leaks before the leak test is concluded. • If there is evidence of leakage, the pressure shall be lowered to 50 psig (350 kPa) before any attempts are made to tighten the fittings. • Testing shall be repeated until leakage is completely eliminated.

8 TEST HEAD ASSEMBLIES AND TEST CAPS

8.1 General Requirements

8.1.1 All temporary and re-usable test-head and test cap assemblies shall meet the minimum design and construction requirements of *49 CFR, Part 192 Subpart D* and *Subpart G* as well as *Part 195 Subpart C* and *Subpart D.*

8.1.2 Welding specifications and procedures used for fabrication, or modification of all temporary and re-usable test head and test cap assemblies shall meet the requirements of *TES-WELD-API Welding of Pipelines and Facilities Specification (US-MEX) (EDMS No. 1001828218)*.

8.1.3 Any transition piece, if required, connected to a test head or test cap assembly shall not be considered a part of the assembly.

8.1.4 For test head and test cap assemblies to be constructed by the Contractor, the Contractor shall use the requirements listed in section 8.2 and/or 8.3 and supply the Company with applicable documentation.

8.1.5 Test (end) cap and test assembly usage:

Table 8-1: Test Cap and Test Assembly Usage

Type	Re-usable	Temporary – One Time Use
Test Head Assembly	Yes	Yes
Test Cap Assembly	Yes	Yes
Test (End) Cap	No	Yes

Refer to 17Appendix C SAMPLE TEST HEAD DRAWINGS.

8.2 Re-usable Test Head and Test Cap Assemblies Requirements

8.2.1 Re-usable test head and test cap assemblies shall also be designed in accordance with *TES-PRES-TH-US Design of Pipeline Test Head Assemblies (EDMS No. 7911901)*.

8.2.2 Maximum working pressure shall be marked on each assembly.

8.2.3 When used for pressure testing, the maximum working pressure of re-useable assemblies shall not:

- produce hoop stresses greater than 80 percent SMYS of any pipe or fitting in the assembly
- be higher than the maximum cold working pressure of any flange or valve in the assembly plus 25 psig (172 kPag)

8.2.4 Re-useable assemblies shall be visually inspected and defects repaired before use and in accordance with *TEF-PRES-TH Test Head Inspection Checklist (EDMS No. 4986590)*.

8.2.5 Re-usable assemblies, to be used at a hoop stress of greater than or equal to 30 percent SMYS of the limiting item of the assembly, shall be pressure tested fully exposed for a minimum of four hours between:

- the minimum pressure of 125 percent of the intended maximum working pressure of the assembly
- the maximum working pressure that will produce a hoop stress not exceeding 100 percent of the SMYS of any pipe or fitting in the assembly, or 150 percent of the cold working pressure rating of any flange or valve in the assembly, whichever is less

8.2.6 Material and pressure testing records shall be maintained for each re-useable assembly for its lifetime. Documentation will be kept in the project file for assembly(s) used.

8.2.7 Re-useable assemblies shall be painted.

8.2.8 Test head assemblies that have been damaged, have incomplete or missing records, or do not meet the requirements outlined above shall be rendered unusable and scrapped.

8.3 Temporary Test (End) Cap and Test Assembly Requirements

8.3.1 Test (end) caps shall only be used once.

8.3.2 Temporary test assemblies shall be designed such that the hoop stress does not exceed 80 percent SMYS at the upper limit of the test pressure range.

8.3.3 Pipe wall thickness, flange rating, and grade of a test assembly shall be determined on a per project basis.

8.3.4 All material documents, including MTRs, and design drawings and test assembly pressure test documentation shall be submitted, as a part of project pre-hydrotest documentation, to the Company's Design Engineer for review.

8.3.5 All piping components of a test assembly shall have a visible heat number.

8.3.6 Lifting stand and/or cradle requirements shall be determined based on project specific needs.

8.3.7 Flanged connections are preferred for NPS 2 or smaller size valves; however, threaded connections are also acceptable.

8.3.8 All pipes must have a joint efficiency factor of 1.0.

8.3.9 Temporary test assemblies may be painted.

8.3.10 Each weld in a temporary test assembly shall be non-destructively inspected.

9 TEST DOCUMENTS

9.1 General Requirements

9.1.1 Pressure test form, pressure test schematic and profile drawings, MTRs, certificates of compliance, certificates of calibration, drawings of the installation location and pressure test plan shall be created and submitted, at least 14 business days before the pressure test is conducted, to the Company's Design Engineer for review and/or approval.

9.1.2 In the event of an emergency pressure test, the pressure test must be approved in advance by the Company Design Engineer.

10 TRAINING AND QUALIFICATION REQUIREMENTS

10.1.1 All individuals who will be responsible for the execution and/or inspection of a Company pressure test in the US shall be qualified to perform pressure testing related covered tasks in accordance with the *Company Operator Qualification Program (EDMS No. 4504739)*.

10.1.2 For Company training requirements refer to *TEN-ME-PRES-GL Pressure Testing Standard (US-MEX) (EDMS No. 1003107276)* and is only applicable to Company individuals.

11 VARIANCES

Any deviation shall follow the Company Management of Change (MOC) Variance Procedure in Table 11-1 below. The Contractor shall contact the Company's Project Engineer for variance approval.

Table 11-1: Variance Procedure & Preferred Role Assignment

	Scope	Procedure	Originator	Owner / Approver	SME	Processor / Implementer
Controlled Document Variance Procedure	Deviations from how work is required to be done by a controlled document (e.g., processes, procedures, standards, work instructions)	EDMS No. 7728702	Project or Operation Eng. / Project Manager	Company's Design Eng. / Responsible Eng.	Responsible Eng.	Company's Design Eng. / Responsible Eng.

12 ROLES AND RESPONSIBILITIES

12.1 Roles

Table 12-1: Examples of Common Role and Responsibilities outlines the typical roles and responsibilities assigned for the use of this Standard. Of the typical roles listed in this section, the Company shall appoint individuals to the applicable pressure testing roles as needed.

Table 12-1: Examples of Common Role and Responsibilities

Role	Responsibilities
Company's Construction Manager	The Construction Manager is responsible for oversight of the field pipeline construction. The Construction Manager manages the commencement of the pressure testing and supervises the Contractors and Inspectors. The Construction Manager is responsible for the handling and use of test heads. The Construction Manager supervises the Pipeline Contractor.
Company's Design Engineer	The Design Engineer is responsible for the final design of the pipeline and for ensuring the pressure test is designed in accordance with this specification, applicable codes, standards and regulations. The Design Engineer can include Integrity and Reliability engineers.
Company's Project Manager	The Project Manager is accountable for all phases of the pressure testing, pressure test calculations, designs and test plans. The Project Manager is accountable for coordinating the inspection and repair of all identified test head damages resulting from field use.

Role	Responsibilities
Company's Test Inspector (CTI)	Company trained and certified to oversee all pressure test activities start to finish.
Company's Test Head Coordinator	Accountable for managing test head inventory and advising project personnel of test head availability. Responsible for maintaining the test head technical information database and the Test Head Central File. This individual/group responsible for the coordination of fabrication, repair and testing of reusable test heads in accordance with industry standards and Company specifications.
Contractor	The third party responsible for conducting the pressure test and for the purpose of this document, it includes the Company Construction Crew.
Company's Test Supervisor	The Test Supervisor is responsible for reviewing technical documentation and contractual requirements, coordinating the activities of the pressure test contractors, and ensuring safe execution of all testing.

12.2 High-Level Responsibilities

12.2.1 The Company shall be accountable for ensuring all pressure test activities conform to this Specification and all pressure test requirements as described in *49 CFR Part 192 and 195*. Pressure testing shall be performed under the direct supervision of the Company's Test Inspector.

12.2.2 Company Specific Roles (Company's Construction Manager, Company's Design Engineer, Company's Project Manager, Company's Test Inspector, Company's Test Supervisor) are personnel designated by the Company to witness, certify or perform pressure testing tasks. A Company Specific Role can be a Company's employee, a Contractor's employee, or a third party Company's employee.

12.2.3 The Contractor and the Company shall provide for the safety of all pipeline construction personnel and the public during pressure test operations.

12.2.4 The Contractor is responsible for all documentation relating to pressure testing, monitoring the testing operations, and checking all data for quality and completeness. The Company is responsible for verifying the documentation listed above, performing quality control and the submission of pressure testing documentation to regulatory authorities, when required. Any questions relating to procedures and documentation should be directed to the Company's Test Inspector for resolution.

12.2.5 The Company's Design Engineer is responsible for the mechanical designs relating to pressure testing and ensures the Pressure Test designs conform to the requirements of this Specification and *49 CFR Part 192* and *195*.

12.2.6 The Company is responsible for securing water permits from the governing authorities for the use and disposal of test water.

12.3 Responsibility Matrix for Engineering and Quality Activities - US

Table 12-2: US – Responsibility Matrix

		Project Manager	Engineer[1,4]		Pressure Test Contractor	Company's Test Inspector	Compliance
			Project / Operations Engineer	Design Engineer[2]			
Pre-Test	Create Calculations and Drawings	A	I/R	R	N/A	N/A	N/A
	Review and Approval Calculations and Drawings	A	R	R	I	N/A	C
	Create Test Plan	A	C	C	R	N/A	C
	Accept Test Plan	A	R	C	I	R	I/C
During Test	Perform Test	A	I	N/A	R	I	N/A
	Monitor and Accept Test	A	C	C	I	R	C
	Adjust Test[3]	A	R*	C	R**	R	C
	Create Test Document Package	A	C	N/A	R	R	N/A
Post Test	Review and Sign-off Test Document Package	A	R	R***	I	R	I
	File Test Document Package	A	R	N/A	N/A	N/A	I

Notes:

[1] For small projects, one individual may take on three roles such as Project/Operations Engineer, Design Engineer, and Project Manager. An independent design discipline check by a degreed engineer shall be conducted for Pressure Test calculations, designs, and test plans.

[2] Design Engineers may be from the Company, or from an external engineering company.

[3] Adjustments include test schedule, equipment failure, conflicts between the Contractor and the Company.

[4] As per TES-ENG-POE Practice of Engineering within TransCanada.

Legend:

A – Accountable; Individual who is ultimately accountable for the activity

R – Responsible; Individual(s) who performs the task/role for the activity

R* – Responsible; Individual(s) who approves the adjusted test plan

R** – Responsible; Individual(s) who shall notify any potential deviations/modifications to the original test plan to the Company for approval and ensures the Pressure Test is performed in accordance with the new approved adjusted test plan

R*** – Responsible; Individual(s) who review the test document package

C – Consult; Individual(s) who is consulted for the activity

I – Inform; Individual(s) who is informed for the activity

N/A – Not Applicable

12.4 Responsibility Matrix for Engineering and Quality Activities - Mexico

Table 12-3: Mexico – Responsibility Matrix

		Project Manager	Engineer[1,5]		Pressure Test Contractor	Company's Test Inspector	Compliance [4]
			Project / Operations Engineer	Design Engineer[2]			
Pre-Test	Create Calculations and Drawings	A	C	C	R	N/A	N/A
Pre-Test	Review and Approval Calculations and Drawings	A	R	R	I	N/A	N/A
Pre-Test	Create Test Plan	A	C	C	R	N/A	N/A
Pre-Test	Accept Test Plan	A	R	R	I	R	N/A
During Test	Perform Test	A	I	I	R	C	N/A
During Test	Monitor and Accept Test	A	C	C	I	R	N/A
During Test	Adjust Test[3]	A	N/A	R*	R**	C	N/A
During Test	Create Test Document Package	A	I	I	R	I	N/A
Post Test	Review and Sign-off Test Document Package	A	I	I	R***	R	N/A
Post Test	File Test Document Package	A	I	I	R	N/A	I

Notes:

[1] For small projects, one individual may take on three roles such as Project/Operations Engineer, Design Engineer, and Project Manager. An independent design discipline check by a degreed engineer shall be conducted for Pressure Test calculations, designs, and test plans.

[2] Design Engineers may be from the Company, or from an external engineering company.

[3] Adjustments include test schedule, equipment failure, conflicts between the Contractor and the Company.

[4] Compliance department in Mexico is the connection of the project with customer and governmental agencies. They inform to them when the test has passed successfully.

[5] As per TES-ENG-POE Practice of Engineering within TransCanada.

Legend:

A – Accountable; Individual who is ultimately accountable for the activity

R – Responsible; Individual(s) who performs the task/role for the activity

R* – Responsible; Individual(s) who approves the adjusted test plan

R** – Responsible; Individual(s) who shall notify any potential deviations/modifications to the original test plan to the Company for approval and ensures the Pressure Test is performed in accordance with the new approved adjusted test plan

R*** – Responsible; Individual(s) who review the test document package

C – Consult; Individual(s) who is consulted for the activity

I – Inform; Individual(s) who is informed for the activity

N/A – Not Applicable

13 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are detailed below in Table 13-1, Table 13-2 and Table 13-3. For Regulatory and External Industry References, use the latest approved edition referenced in CFR Title 49 Part 192 and 195. For Internal References, use the latest document revision, unless otherwise approved by the Company.

Table 13-1: Regulatory References

Organization/Document No.	Title
CFR Title 49 Part 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
CFR Title 49 Part 195	Transportation of Hazardous Liquids by Pipeline
NOM-007-SECRE-2010	Transport of Natural Gas

Table 13-2: External Industry References

Organization/Document No.	Title
ANSI/ASME B31.3	Process Piping
ANSI/ASME B31.4	Liquid Transportation System for Hydrocarbons
ANSI/ASME B31.8	Gas Transmission Distribution and Piping Systems
ANSI/GPTC Z380.1	Guide for Gas Transmission and Distribution Piping Systems
API RP 1110	Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids or Carbon Dioxide

Table 13-3: Internal References

Document No.	Title
EDMS No. 7911901	TES-PRES-TH-US Design of Pipeline Test Head Assemblies
EDMS No. 4986590	TEF-PRES-TH Test Head Inspection Checklist
EDMS No. 1001828218	TES-WELD-API Welding of Pipelines and Facilities Specification (US-MEX)
EDMS No. 1003107361	TEP-ME-PRES-GL Pressure Testing Procedure (US-MEX)
EDMS NO. 1003430939	TEF-ME-PRES-GL Pressure Test Form (US-MEX)

14 DOCUMENTATION AND RECORDKEEPING

Due to the broad range of data types that may be required in support of this Specification, there are a number of repositories that may need to be utilized for documentation purposes. A summary of key data repositories appears in Table 14-1.

Table 14-1: Documentation Requirements

Documentation Description	Repository / Link
TEF-ME-PRES -GL Pressure Test Form	Project Specific Binder

15 DOCUMENT HISTORY

Rev.		
00	**Description**	**Effective Date**
	This Specification contains pressure testing engineering design requirements. The content has been derived from previous pressure testing specification *TES-HYDRO-HTS-US*.	2018-Jan-01
	Rationale Statement	**Responsible Engineer**
	This Specification is a new document. It has been simplified and all procedural content has been moved to *TEP-ME-PRES-GL*. This document was developed as part of Engineering Standards Streamlining Process. This document was developed / revised in order to address the following requirements: • Consolidation of TransCanada specifications. The following specifications/documents have been combined into this document: – *TES-HYDRO-HTS-US* • Consolidation of CPG specifications. The following specifications/documents have been combined into this document: – Piping Testing Requirements Plan – Auxiliary Piping Design, Inspection and Testing Plan – Hydrostatic Test Water – Liquid Piping Testing Requirements Plan • Improved clarity • Mexican requirements in accordance with *NOM-007-SECRE-2010*.	Vivian Liu
	Impact Assessment Summary	**Document Owner**

Rev.		
	The following parties are to refer to this newly created Specification: • U.S. pipeline and facility projects • Mexico pipeline and facility projects This Specification requires that Company individuals involved in pressure testing activities complete classroom pressure testing training. Natural Gas is permitted as a test medium with safety test plan and Company approval. Temporary test head assemblies are included to support project needs.	Vivian Liu

16 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
NOM-007-SECRE-2010	New requirements to be considered
Industry Standards	
N/A	N/A
General	
• Aligned Specification to common U.S. terminology. • Separated gas and liquid pressure testing requirements where possible • Clarified pressure testing roles. Align roles and responsibilities with U.S. and Mexico organizational structure. • Allowed the project to use temporary test head assemblies. • Added service line and plastic line pressure testing requirements. • Added pressure testing requirements for auxiliary piping and tubing. • Added non-pressure tested field welds justifications.	

17 APPROVALS

APPROVALS		
Originator: David Scalzo, P. Eng. Design Services – FIDE	Signature	April, 25, 2017 Date
Reviewer: Masroor Husain, P.Eng. Design Services – FIDE	Signature	APRIL 25, 2017 Date
Reviewer: Gerard Lalonde, P.Eng. Design Services – FIDE	Signature	4/25/2017 Date
Reviewer: Dawood Habib, P.Eng. Design Services – FIDE	Signature	4/25/2017 Date
Reviewer: Gary Hawthorne US Project Engineering	Signature	4/25/2017 Date
Reviewer David Anderson US Regulatory Compliance	Signature	4/26/17 Date
Reviewer: Lee Romack Manager, US Regulatory Compliance	Signature	4-28-2017 Date
Reviewer: Eric House US Project Engineering	Signature	4/26/2017 Date
Reviewer: Sandy Robinson US Project System Maintenance & Implementation	Signature	Date 2017 APRIL 4 Date
Reviewer: Gustavo Marcelo Guaytima MEX Quality & Internal Compliance	Signature	MARCH 27th 2017 Date
Reviewer: Jason Lopez US & MEX Construction Management Services	Signature	2017/04/26 Date
Reviewer: Stan Parrish, US Principal Engineer ,Integrity Eng. Services East	Signature	4/27/17 Date
Reviewer: Paul Shaffer US Construction Compliance Manager	Signature	4/26/2017 Date
Responsible Engineer: Vivian Liu, P. Eng. Design Services – FIDE	Signature May 03, 2017 Date	PROFESSIONAL ENGINEER VIVIAN LIU ALBERTA APEGA Permit to Practice P7100
Management Endorsement: Riaz Muhammad, Manager Design Services – FIDE	Signature	MAY 4, 2017 Date

APPENDIX A (NON-MANDATORY) – EXAMPLES OF NON-PRESSURE TESTED WELD LOCATIONS OF PIPELINE ASSEMBLIES

A-1 SIDE VALVE INSTALLATION

A-1-1 BY HOT TAP

When a new side valve assembly is required on an existing pipeline using a hot tap there will be one non-pressure tested weld to connect the valve assembly pipe to the stub, which has been previously welded to the pipeline.

Rationale:

The only weld that is required is the weld between the prefabricated valve assembly and the stub on the existing pipeline. The weld completed to attach the stub to the mainline and the structural welds completed on the reinforcement saddles cannot be safely pressure tested due to the hydrostatic pressure that would be applied to the external surface of the run pipe.

Note:

The weld count does not include branch connection welds (buttering weld layers, run pipe to stub grove/fillet weld), or any reinforcement fitting to pipe welds which are considered intrinsic to the reinforcement and hot-tapping process.

A-1-2 BY INSTALLATION OF A TEE

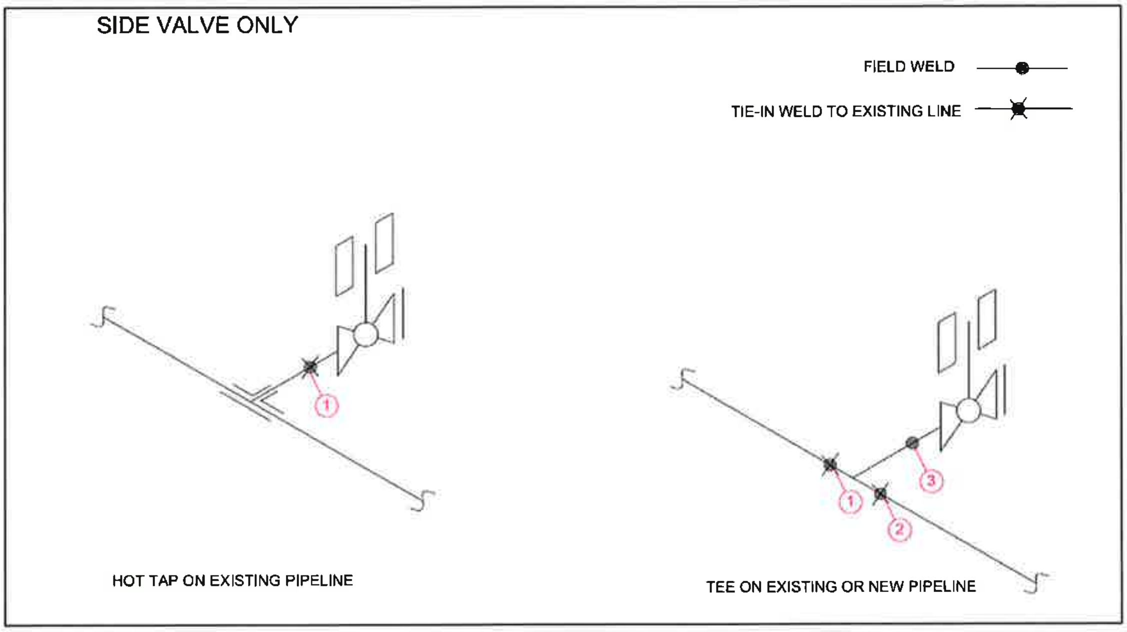
When a new side-valve assembly is required on an existing pipeline using a tee the number of non-pressure tested welds may be limited up to three.

Rationale:

Two welds are required to install the tee into the pipeline (weld 1 and 2) and one weld is required to weld the prefabricated valve assembly to the branch of the tee (weld 3). Weld 3 is required to ensure that the valve and stem are installed plumb (vertical). This is important to ensure proper functionality of the valve operator. The maximum allowable offset for the stem and operator is +/-4 degrees from vertical.

Alternative:

If survey information for the existing pipeline exists and can verify that the line is flat, the valve and tee assembly can be prefabricated and hydrotested in the fabrication shop. This would eliminate one non-pressure tested weld (weld 3). Note however that this design suffers from the risk that the existing pipe may spring out of its flat alignment when cut, so it is to be used with caution.



Appendix Figure A-1: Side Valve Installation

A-2 METER STATION

Meter stations will be hydrotested in the field after fabrication, if required. Regardless of whether there is a single meter run or multiple meter runs, the installation may have up to four (4) non pressure-tested welds.

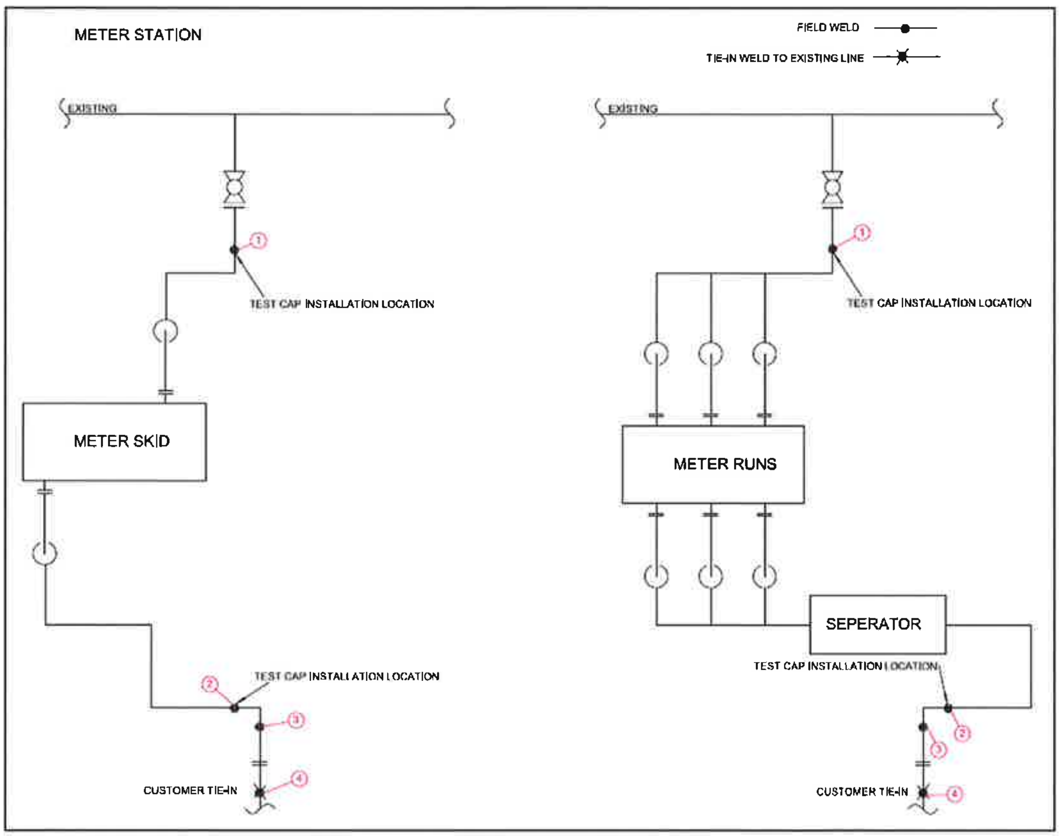
Rationale:

- Test caps will be utilized at both ends of the meter station yard piping.
- The Company side of the meter station will be tested from the test cap to the meter run flange(s). Due to limited space at the hot tap valve location a test cap is used instead of using the flange at the valve.
- The customer side of the meter station will be tested from the meter run flange(s) to the test cap. A test cap is used rather than breaking the pretested flange and insulating set assembly. The test cap location is due to the required location of the flange set. The insulating flange at the customer tie in point is placed 1 meter from the meter station boundary. This is to minimize the amount of pipe that is not protected by cathodic protection while maintaining the insulating set on the meter station boundary. Welds 1, 2, and 3 are due to the test caps and weld 4 is the final tie in to the customer.

Alternative:

- When space permits the Company side of the meter station shall be tested to the flange. This would eliminate one (1) of the non-pressure tested welds.

- On the customer side, rather than use a test cap, the flange and insulating set assembly shall be taken apart and the piping should be tested to the flange. This option increases the risk for potential leaks in the flange. This would however eliminate two (2) non-pressure tested welds.
- When space permits the test cap could be placed at weld three (3) which would eliminate one (1) non-pressure tested weld.



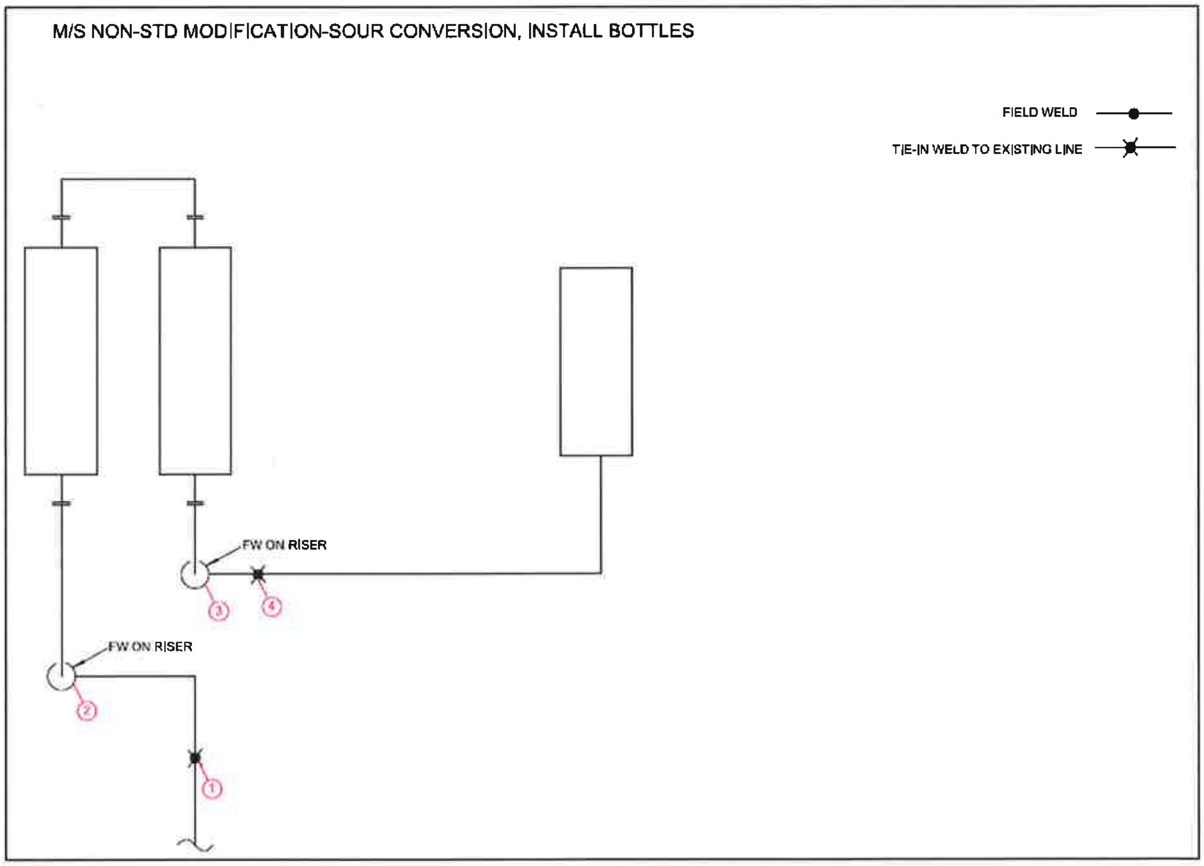
Appendix Figure A-2: Meter Station

A-3 SOUR CONVERSION ON EXISTING METER STATION

A sour conversion on an existing meter station may require the addition of one or multiple sour bottle(s). The number of non-pressure tested welds may be up to four.

Rationale:

The pipe connecting the existing station and the sour bottle(s) will require shop and field hydrotest. Some flexibility in the design is required due to the possible difference in elevation between the meter building, the sour bottles and the final tie in. Once the pipe has been field fit it can be field hydrotested. There will be two non-pressure tested welds on the risers on either side of the sour bottles to ensure a stress-free tie in and two non-pressure tested welds to tie the new pipe to the existing pipe.



Appendix Figure A-3: Sour Conversion on Existing Meter Station

A-4 NEW BLOCK VALVE ASSEMBLY ON NEW OR EXISTING PIPELINE

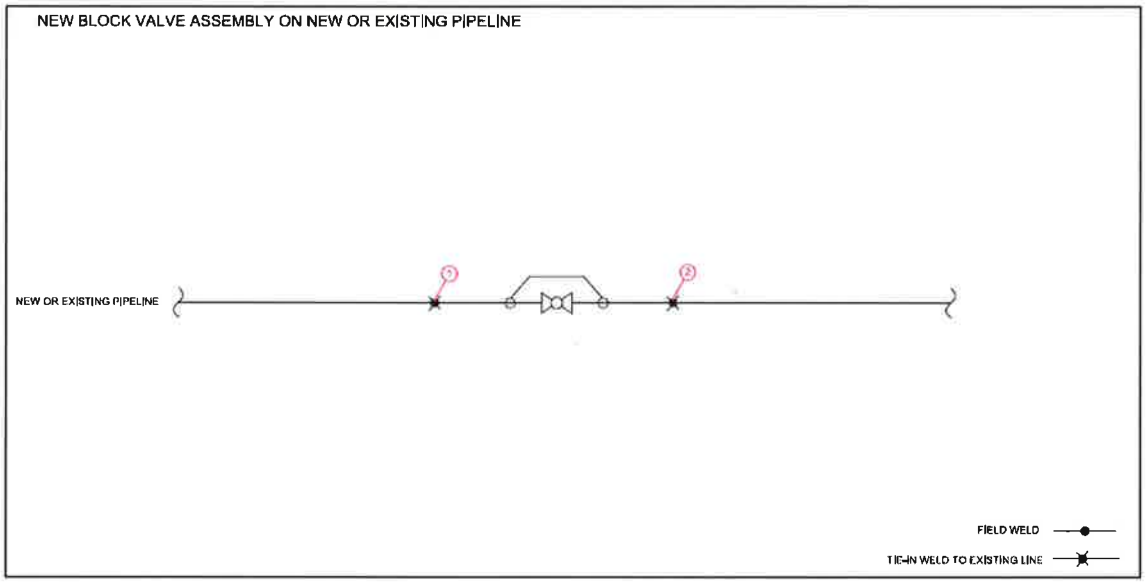
When installing a block valve there may be two non-pressure tested welds. Pre-fabricated and tested block valve assembly must include any required transitions to the existing pipe wall thickness.

Rationale:

The block valve assembly will be shop fabricated and hydrotested, or assembled and hydrotested on site depending on the size of the assembly. Regardless, there will be two tie in welds required for the installation of the assembly into the pipeline.

Alternative:

If the block valve assembly is installed on a new pipeline it could be hydrotested with the pipeline subject to evaluation of the risks and mitigations.



Appendix Figure A-4: New Block Valve Assembly on New or Existing Pipeline

A-5 THREE VALVE CLUSTER AT PUMP STATION INSTALLED ON NEW OR EXISTING PIPELINE

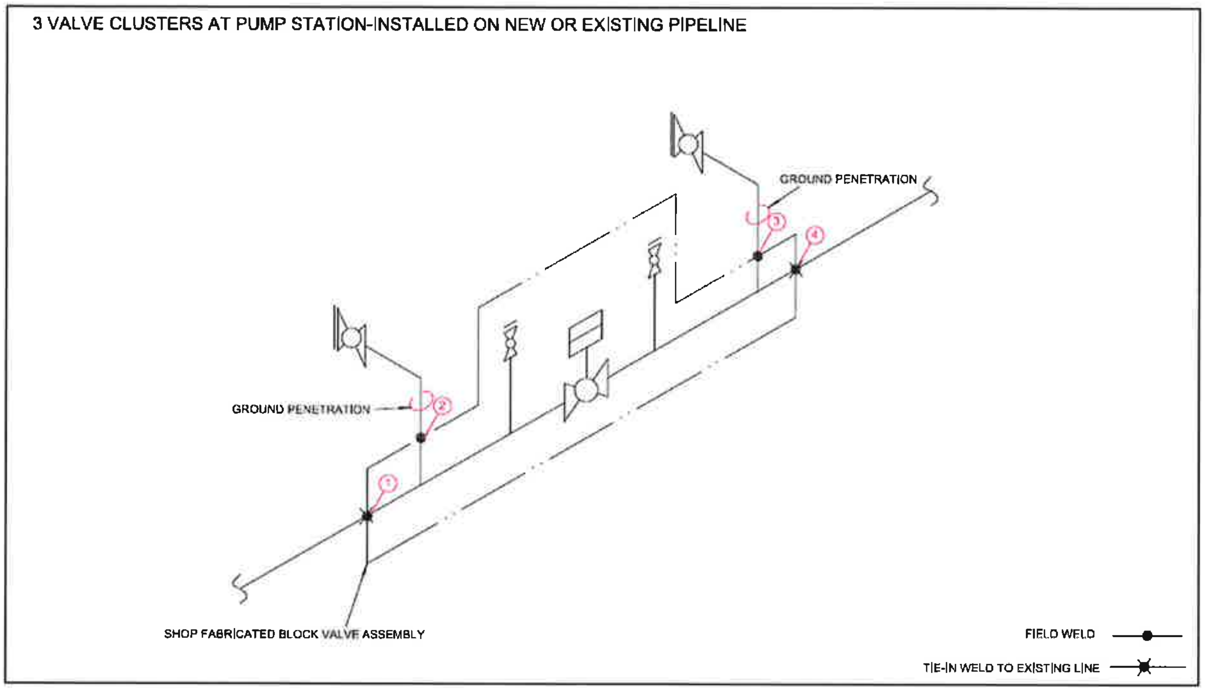
The three-valve cluster consists of a prefabricated block valve assembly complete with two pump outs and two side valves to connect the pump station. This layout may have up to four non-pressure tested welds.

Rationale:

Welds 1 and 4 are required to tie the valve assembly into the pipeline and weld 2 and 3 are required for a stress-free installation of the two side valves.

Alternative:

If the three-valve cluster is on a new pipeline it could be hydrotested along with pipeline subject to evaluation of the risks and mitigations.



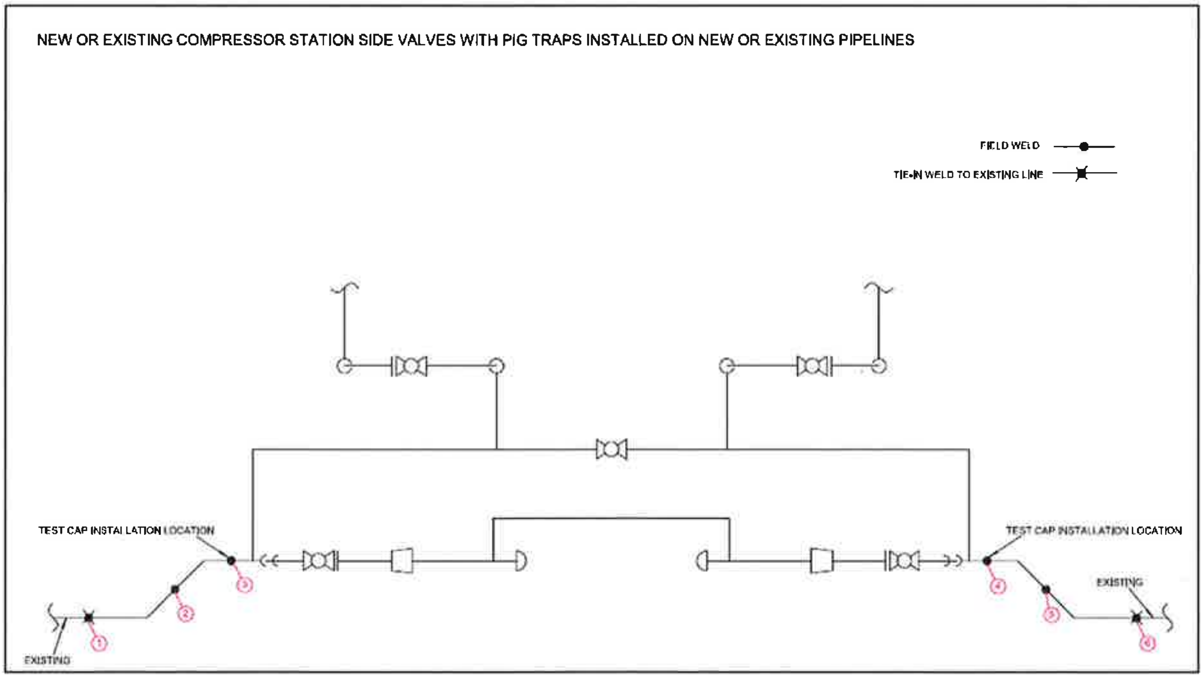
Appendix Figure A-5: Three Valve Cluster at Pump Station Installed on New or Existing Pipeline

A-6 NEW OR EXISTING COMPRESSOR STATION SIDE VALVES WITH PIG TRAPS INSTALLED ON NEW OR EXISTING PIPELINE

This layout may result in six non-pressure tested welds. The pig trap and compressor station side valves are offset from the existing pipeline to reduce the outage on the existing pipeline and to allow for a stress-free tie in to the existing pipeline.

Rationale:

Two test caps will be installed, one on each side of the assembly, to facilitate a field hydrotest of all piping up to the flanges on the compressor station side valves. Once the test is complete the final tie in to the new or existing pipe will be done. To ensure a stress-free tie in there will be three non-pressure tested welds on either side to complete the tie in.



Appendix Figure A-6: New or Existing Compressor Station Side Valves with Pig Traps Installed on New or Existing Pipeline

A-7 NEW PIPELINE SIDE VALVE AND NEW PIG TRAP

When a new side valve assembly and pig trap are required, the number of non-pressure tested welds may be up to eight plus those required to tie-in the kicker line Refer to the side valve tie in options for the kicker line tie in welds (one or three depending on which option is chosen).

The flanged portion of the kicker line shall be field tested to eliminate any non-pressure tested welds on this section of pipe.

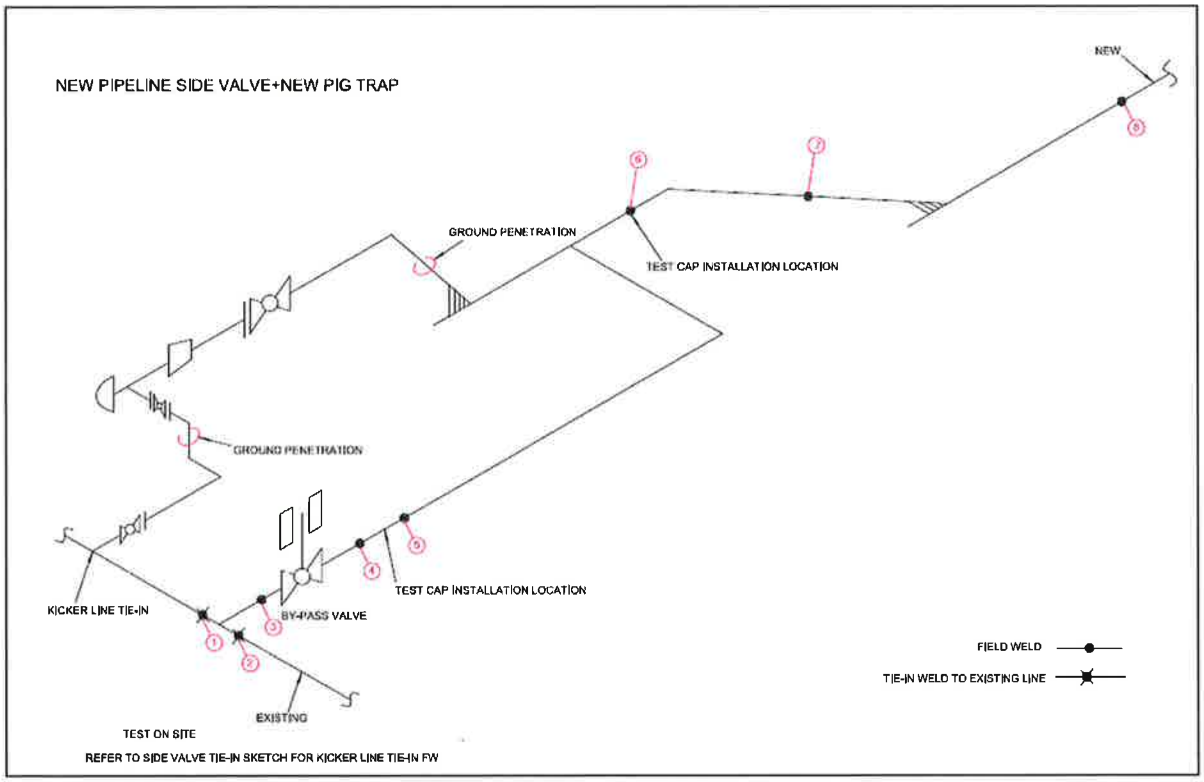
Rationale:
Welds 1 and 2 are required to install the tee into the existing pipeline, weld 3 is to weld the prefabricated valve assembly to the tee and is required to ensure that the valve is installed straight and the stem plumb (vertical). This is important to ensure proper functionality of the valve operator. The maximum allowable offset for the stem and operator is +/- 4 degrees from vertical. Welds 4 and 5 are required for the installation of one test head. Welds 6 and 7 are to ensure a stress-free tie in and weld 8 is for the final tie in to the pipeline.

Alternative:

- If possible a hot tap could be used for the connection of the bypass valve which would eliminate welds 1 and 2.
- If survey information for the existing pipeline exists and it can be verified that the existing line is flat the valve and tee assembly can be prefabricated. Perform a

shop hydrotest of the assembly. This would eliminate one non-pressure tested weld (weld 3).

- The test cap on the downstream side of the assembly could be placed near weld 8. This would allow weld 6 and 7 to be hydrotested. This would result in a second non-pressure tested weld near weld 8 where a section of pipe would need to be installed once the test cap was removed. This alternative would result in one less non-pressure tested weld, a total of 7, but would not have the benefits of the stress-free tie-in.



Appendix Figure A-7: New Pipeline Side Valve and New Pig Trap

A-8 INSTALLATION OF A STANDARD PIG TRAP NPS 24 OR LARGER ON EXISTING PIPELINE

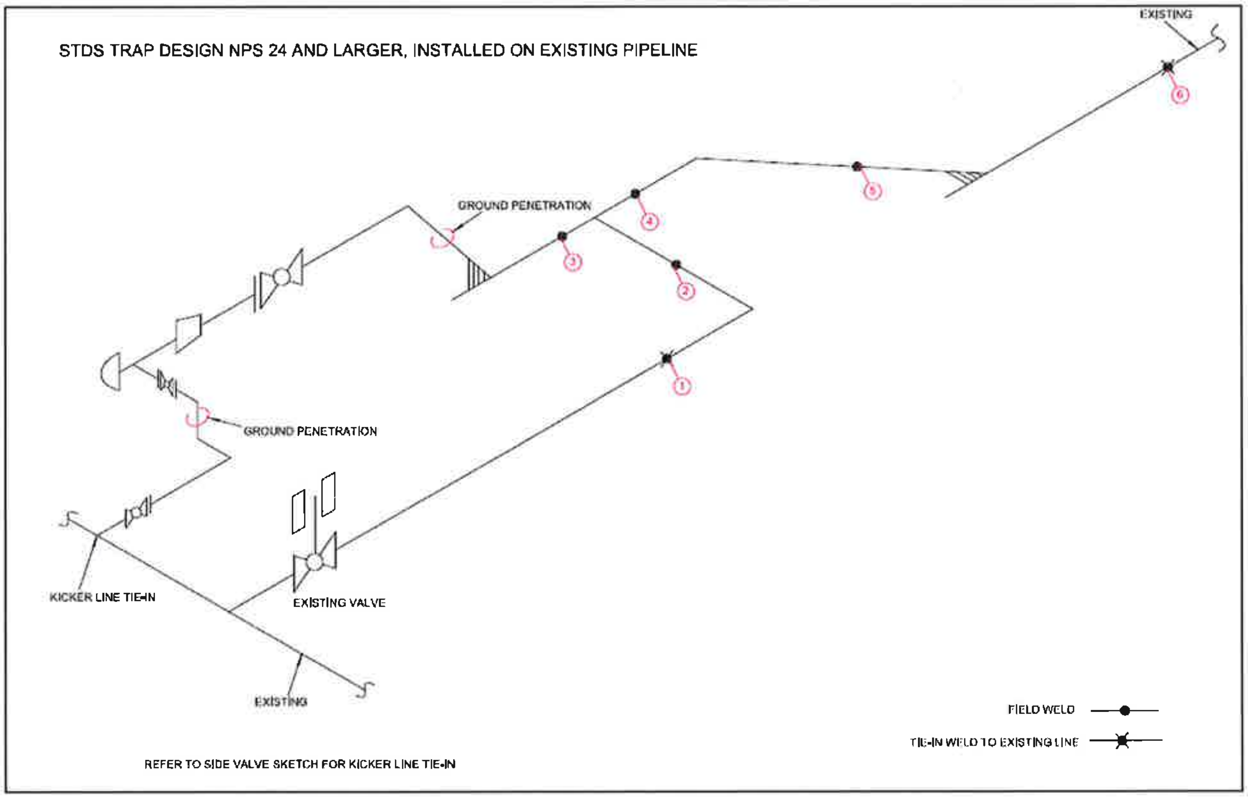
When installing a NPS 24 or larger standard pig trap on an existing pipeline the number of non-pressure tested welds may be up to six plus those required to tie-in the licker line. Refer to the side valve tie in options for the kicker line tie in welds (one or three welds depending on which option is chosen). Most of the pig trap piping will be tested in place. This will require the installation of two test caps. The flanged portion of the kicker line will be removed and tested in the field.

Rationale:

Since this is a new pig trap on an existing pipeline it is very difficult to test all pipe in place. The six non-pressure tested welds are to ensure a stress-free tie in.

Alternative:

Test caps could be installed on either end of the piping, which would result in four non-pressure tested welds. This is two less than the original design but the addition of two non pressure-tested welds to have adjustability for a stress-free tie in is the preferred option.



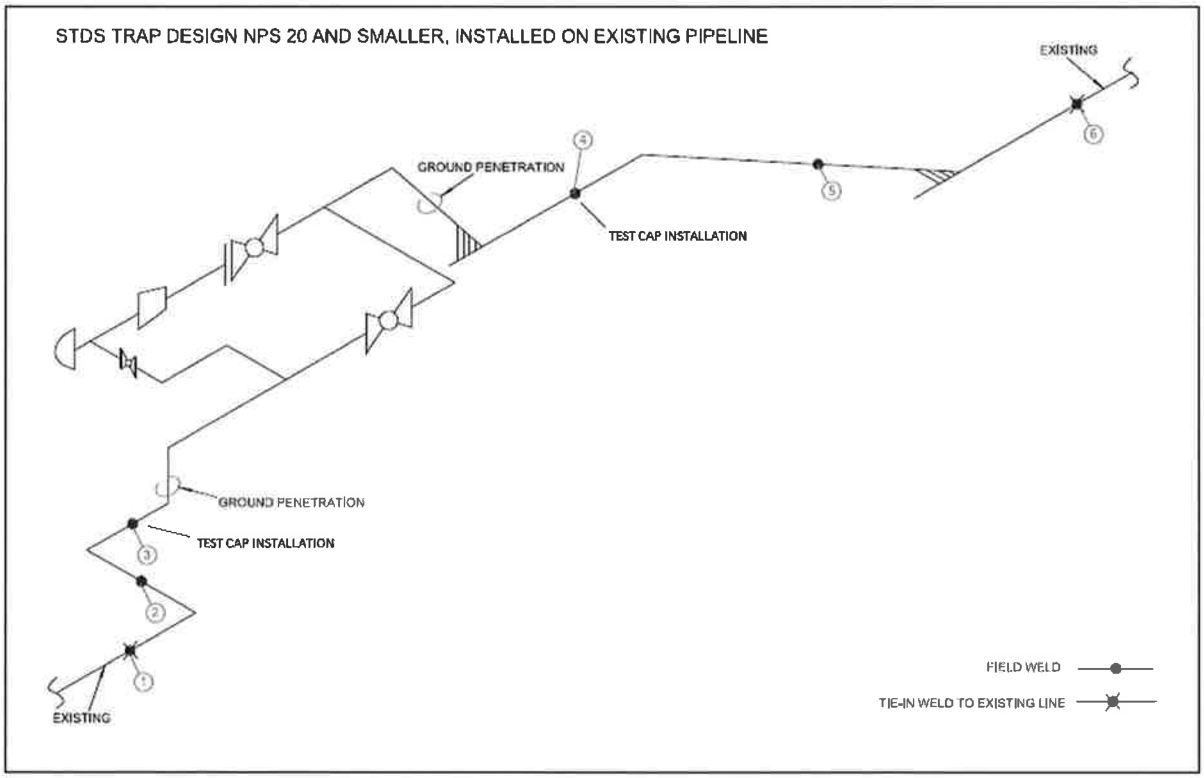
Appendix Figure A-8: Installation of a Standard Pig Trap NPS 24 or Larger on Existing Pipeline

A-9 INSTALLATION OF A STANDARD PIG TRAP NPS 20 OR SMALLER ON EXISTING PIPELINE

When installing a NPS 20 or smaller standard pig trap on an existing pipeline the number of non-pressure tested welds may be up to six plus those required to tie-in the kicker line. Refer to the side valve tie in options for the kicker line tie in welds (one or three welds, depending on which option is chosen).

Rationale:

Test caps shall be placed at welds 3 and 4. This location is chosen as it allows for the required space necessary to perform a safe hydrotest. The six non-pressure tested welds are required for a stress-free tie in to the pipeline.



Appendix Figure A-9: Installation of a Standard Pig Trap NPS 20 or Smaller on Existing Pipeline

A-10 PIPELINE LOOP AND CROSSOVER

The number of non-pressure tested welds is dependent on the type of tie in that is used on both the new and existing pipelines as well as whether the valve is located near the existing pipeline or the new pipeline.

A-10-1 TEE ON NEW AND EXISTING PIPELINES AND VALVE LOCATED NEAR THE EXISTING PIPELINE

This design is required when the outage on the existing pipeline is prior to the construction of the new pipeline. There may be up to eight non-pressure tested welds

Rationale:

There will be two non-pressure tested welds on the tee which is installed on the existing line (weld 1 and 2), one for the installation of the valve (weld 3), three on the tee being installed on the new line (weld 6, 7 and 8), and two non-pressure tested welds on the crossover pipe to allow for a stress-free tie-in (weld 4 and 5). Weld 3 is required to ensure that the valve is installed straight and the stem plumb (vertical). This is important to ensure proper functionality of the valve operator. The maximum allowable offset for the stem and operator is +/-4 degrees from vertical.

Alternative:

- If survey information for the existing pipeline exists and it can be verified that the line is flat the valve and tee assembly can be prefabricated. Perform a shop hydrotest of the assembly. This would eliminate one non-pressure tested weld (weld 3).
- After the crossover pipe is in place the section from weld 4 to 6 could be removed and hydrotested. This would eliminate one non-pressure tested weld (weld 5). Weld 4 and 6 would still be non-pressure tested as they are required to tie in the crossover pipe. This would result in a total of seven non-pressure tested welds. This hydrotest could be done up to the flange which would then result in six non-pressure tested welds. This would require unbolting the pretested flange assembly which may result in an increased potential for leaks.

A-10-2 TEE ON NEW AND EXISTING PIPELINES AND VALVE LOCATED NEAR THE NEW PIPELINE

This design is required if the new pipeline is installed prior to the outage on the existing line. There may be up to eight non-pressure tested welds.

Rationale:

There will be three non-pressure tested welds on the tee which is installed on the existing line (weld 1, 2 and 3), two on the crossover pipe to allow for a stress free tie in (weld 4 and 5), one for the installation of the valve (weld 6), and two on the tee being installed on the new line (weld 7 and 8). Weld 6 is required to ensure that the valve is installed straight and the stem plumb (vertical). This is important to ensure proper functionality of the valve operator. The maximum allowable offset for the stem and operator is +/-4 degrees from vertical.

Alternative:

- If the new pipeline is flat the valve and tee assembly can be prefabricated. Perform a shop hydrotest of the assembly. This would eliminate one non-pressure tested weld (weld 6).

- After the crossover pipe is in place the section from weld 3 to 5 could be removed and hydrotested. This would eliminate one non-pressure tested weld (weld 4). Weld 3 and 5 would still be non-pressure tested as they are required to tie in the crossover pipe. This would result in a total of seven (7) non-pressure tested welds. This hydrotest could be done up to the flange which would then result in six (6) non-pressure tested welds. This would require unbolting the pretested flange assembly which may result in an increased potential for leaks.

A-10-3 TEE ON NEW PIPELINE AND HOT TAP ON EXISTING PIPELINE

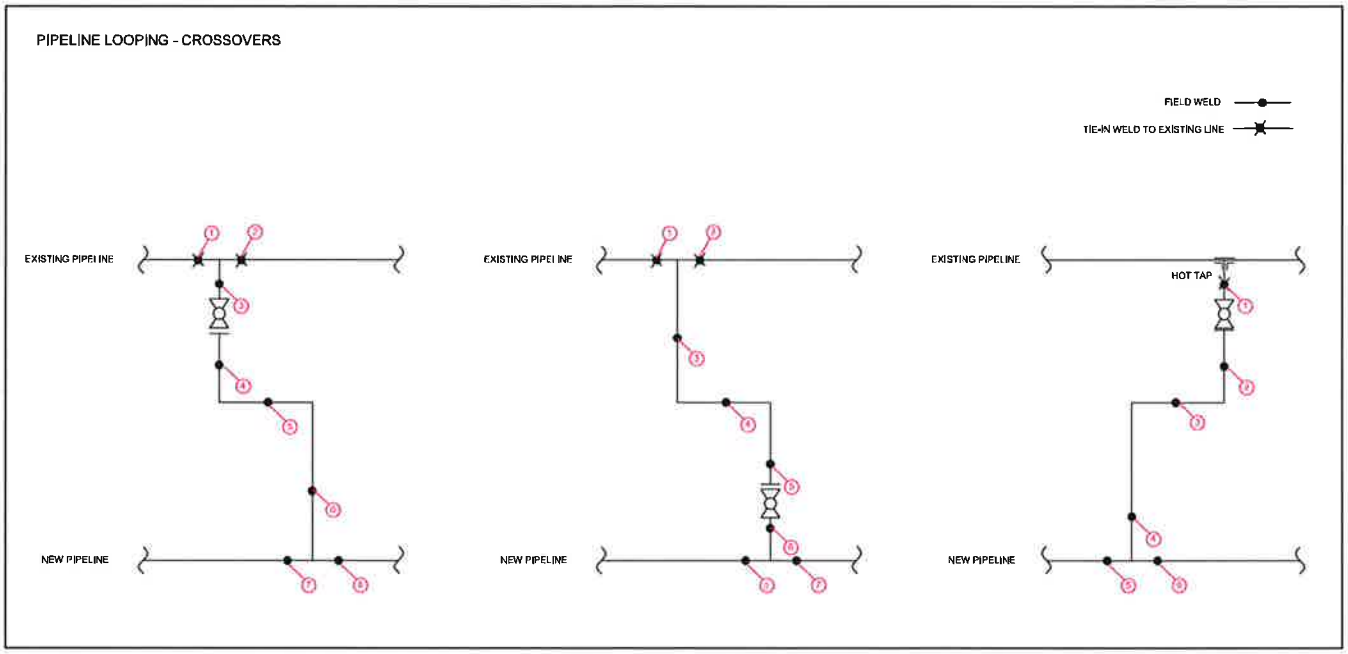
For this installation the valve is located near the existing pipeline. There may be up to six non-pressure tested welds.

Rationale:

There will be one for the hot tap on the existing line (weld 1), two non-pressure tested welds on the crossover pipe to allow for a stress free tie-in (weld 2 and 3), and three non-pressure tested welds on the tee which is installed on the new line (weld 4, 5 and 6).

Alternative:

- To eliminate the non-pressure tested welds on the tee installed on the new pipeline (weld 5 and 6) a test cap would need to be installed on the tee to allow it to be tested with the new pipeline. This would eliminate two non pressure-tested welds and the total would then be four.
- After the crossover pipe is in place the section from weld 2 to 4 could be removed and hydrotested. This would eliminate one non-pressure tested weld (weld 3). Weld 2 and 4 would still be non-pressure tested as they are required to tie in the crossover pipe. This would result in a total of five non-pressure tested welds. This hydrotest could be done up to the flange which would then result in four non-pressure tested welds. This would require unbolting the pretested flange assembly which may result in an increased potential for leaks.



Appendix Figure A-10: Pipeline Loop and Crossover

A-11 PIPE REPLACEMENT

A-11-1 SINGLE JOINT

When replacing one joint of pipe (for an integrity dig or reinstating a pipeline following a hydrotest for example), there may be up to two non-pressure tested welds

Rationale:

The replacement pipe, including any required counter bore and taper transitions, will be pre-tested in either shop or field. There will be two tie in welds required for the installation of the pretested pipe into the pipeline.

Alternative:

In cases where the pipeline moves/springs upon cut out or the actual pipeline alignment differs from what was assumed based on drawings and survey, a third weld (weld 3) may be added at one of the locations shown for stress free tie-in and weld alignment.

A-11-2 PIPE REPLACEMENT – TWO JOINTS OR MORE

When replacing more than one joint of pipe, there will be two (2) non-pressure tested welds

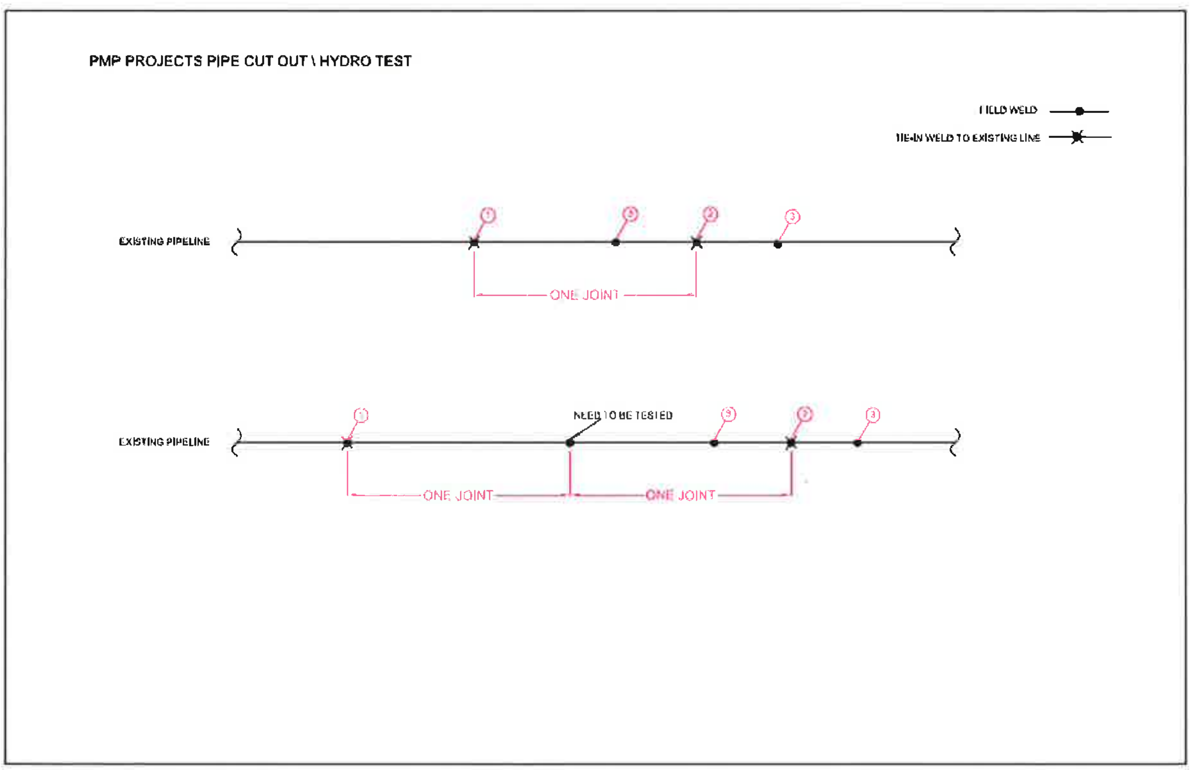
Rationale:

If the overall size is transportable, the replacement pipe will be shop fabricated and hydrotested and there will be two tie in welds required for the installation of the pretested pipe into the pipeline.

If the overall size is too long for transportation, the replacement pipe will be field hydrotested, there will be two tie in welds required for the installation of the field-tested pipe into the pipeline.

Alternative:

In cases where the pipeline moves/springs upon cut out or the actual pipeline alignment differs from what was assumed based on drawings and survey, a third weld (weld 3) can be added at one of the locations shown for stress free tie-in and weld alignment.



Appendix Figure A-11: Pipe Replacement – Single and Multi-Joint

APPENDIX B SCHEDULE OF NON-PRESSURE TESTED WELDS (SAMPLE FORM)

Project Name:	
Project Number:	
LSD:	
FIA Number:	

Weld Code or Number	**Drawing Reference #** (Plot Plan, Isometric, Tie-in Sketch)	**Justification** (if Not Tested)	**TEF-WELD-TIE-IN Completed** (Initials)

Contractor's Inspector: Name ______________________ Signature ______________________

Owner's Inspector: Name ______________________ Signature ______________________

APPENDIX C SAMPLE TEST HEAD DRAWINGS

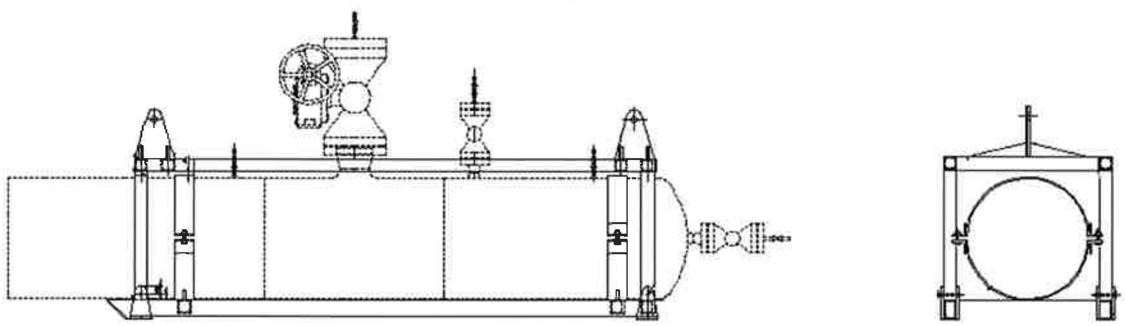


Figure C-1: Sample Test Head with Cradle Layout

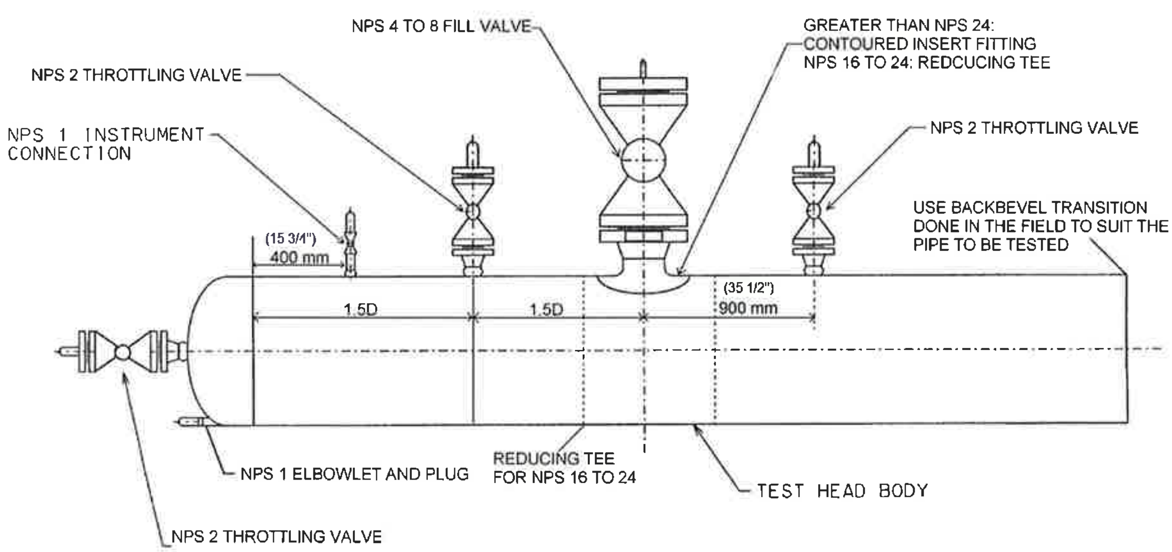


Figure C-2: Sample Test Head Layout (NPS 16 to NPS 48)

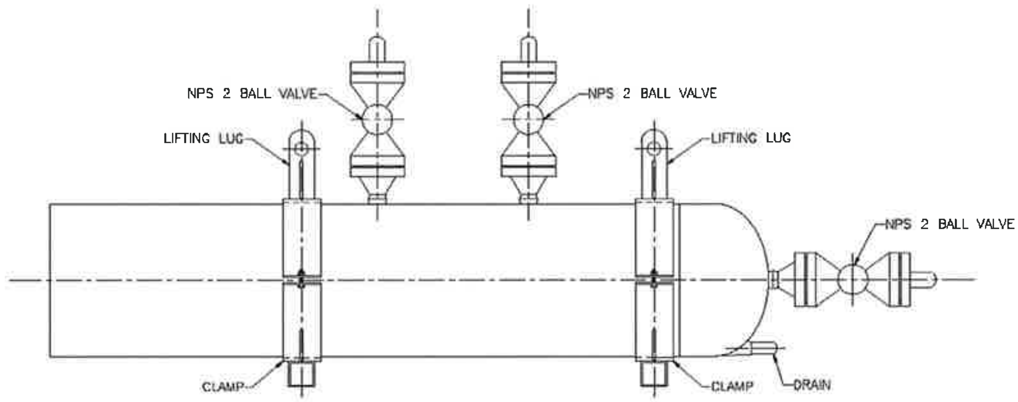


Figure C-3: Sample Test Cap Layout (NPS 12 to NPS 48)

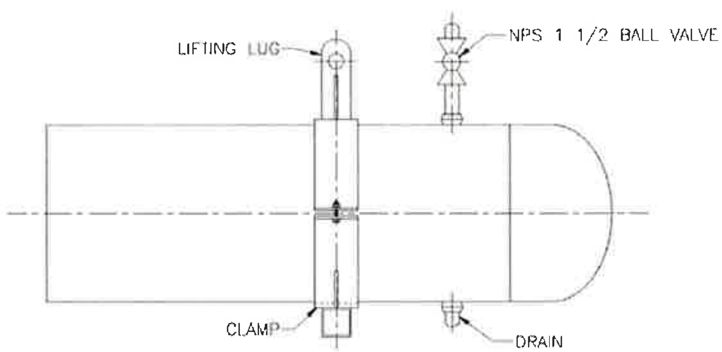


Figure C-4: Sample Short Test Cap Layout (NPS 12 to NPS 48)

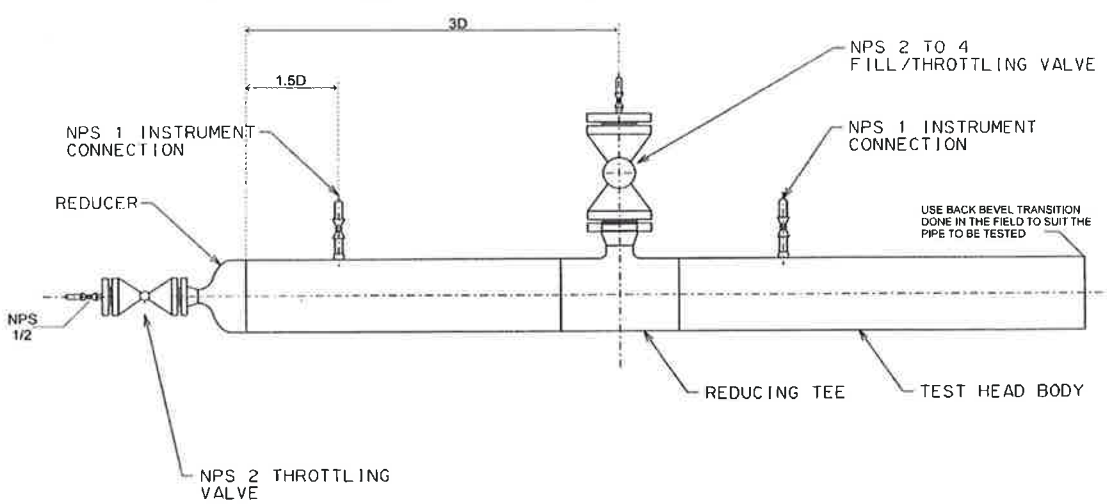


Figure C-6: Sample Test Head Layout (NPS 3 to NPS 12)

PURPOSE

This Specification describes the minimum requirements for external liquid coatings to be used for below ground corrosion control on pipelines and facilities.

SCOPE / APPLICABILITY

This Specification covers shop and field-applied external liquid coatings and includes requirements for:

- Application
- Inspection
- Handling
- Repair and maintenance

This Specification also covers holiday detection and repairs to fusion bond epoxy (FBE) coating with liquid coatings.

This Specification applies to Canada, the United States and Mexico.

U.S. and Mexico projects shall follow the body of this Specification for all coating application except the requirements listed in APPENDIX B. Canadian projects shall follow the body of this Specification, APPENDIX B, and the coating Manufacturer's Qualified Application Procedure (MQAP).

The following activities fall outside of the scope of this document:

- Coating of Mueller tees
- Sealing above ground support sleeves to eliminate water migration through the sleeve
- Coating the edge transition of clamps

Find details on these activities in TES-COAT-PET (EDMS No. 7756).

The Applicator Selection Process falls outside of the scope of this Specification.

Contact the Responsible Engineer for clarification.

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1 GLOSSARY

ABR

Abrasion resistant coating also known as ARO or abrasion resistant overlay which is to be used in abrasive conditions.

Applicator

Company responsible for the actual application of the coating. Typically, this is either the Contractor or their sub-Contractor.

Cohesive Failure

The separation of the homogeneous coating. Coating left on the steel substrate and coating forced off during evaluation.

Company

TransCanada, including its affiliates, engineering agencies, inspectors and other authorized representatives.

Company Coating Inspector

A designated coating inspector hired by the Company for the duration of the Project.

DFT

Dry film thickness, the thickness of the coating after it has hardened to a solid state, as defined in SSPC PA2.

Epoxy

A two-component liquid epoxy coating system.

Liquid Coating

A coating material, consisting of two or more parts in a fluid state, that when mixed together and applied to the substrate hardens to form a solid coating. Usually formulated from epoxy or urethane resins. Also referred to as 'two-component liquid epoxy' or "two-part epoxy coating".

Pre-fabricated valve assemblies

Pre-fabricated valve assemblies are assemblies that have been bolted/welded together. Pipe pups, valves, elbows, check valves and flanged items that are already fabricated prior to coating and to be installed as one piece into the facility being constructed.

Service Temperature

The maximum operating temperature that the coating will see during its lifecycle

Single Gauge Reading

One single reading taken by a DFT gauge.

Sweating/Damp Pipe (Substrate)

Any substrate to be coated or abrasive blasted is considered to be sweating or damp if its temperature is less than 3 Celsius degrees (3C°) (5 Fahrenheit degrees (5F°)) above the dew point of the air immediately adjacent to the surface.

System 1A

Single-layer fusion bond epoxy (FBE) corrosion coating.

System 2B

Two-layer fusion bond epoxy (FBE) coating (comprised of a corrosion coating (System 1A) and an abrasion resistant overcoat).

Turnover Package

Contractor generated coating application QA/QC records for the project with required calibration certificates included.

WFT

Wet film thickness. The thickness of the coating film while in the liquid state.

Tape

Over the ditch mechanically applied or hand-wrap tape systems, excluding petrolatum tape system.

2 REQUIREMENTS

2.1 General Requirements

2.1.1 Wherein the Manufacturer's literature, governmental or regulatory requirements conflict with this Specification, the more stringent requirement shall govern.

2.1.2 The Applicator is responsible to adhere to the requirements outlined in this Specification.

2.1.3 Prior to bidding, the Applicator's personnel shall be Manufacturer trained and certified for the specified product application.

2.1.4 Certification shall be renewed annually.

2.1.5 Copies of all certificates of qualification shall be supplied to the Company's onsite Coating Inspector for review and acceptance.

2.1.6 The Company shall approve all Plural Component Spray and Automated Spray Application companies prior to award of bid.

2.1.7 The Applicator shall provide at least one NACE certified CIP Level I or Company approved alternatively trained employee at their shop or field location. This employee shall perform inspections and supervise other employees conducting inspections. This employee shall have thorough knowledge of the application procedures used for high performance coatings and be competent with procedures used to apply liquid coatings.

2.1.8 The Applicator shall ensure compliance with all applicable regulations, codes, standards, and specifications.

2.1.9 Below ground metallic components (e.g., girth welds, piping, valves, fittings, and structural steel) shall be coated according to APPENDIX A. Items shall be handled in such a manner so as to prevent them from being damaged.

2.1.10 In addition to the Manufacturer's training, Plural Component and Automated Spray Applicators shall have one of the following:

- The Society for Protective Coatings (SSPC) QP1 or QP3 certifications as applicable
- National Association of Corrosion Engineers (NACE) NIICAP AS-1 accreditation
- ISO 9001 Quality Management Standard certifications
- A documented company Quality Management System

2.1.11 The Applicator shall submit an inspection and test plan (ITP) for the Project for the supply and application of coating materials to the Company's onsite Coating Inspector or Responsible Engineer prior to the commencement of work. The ITP is a live document. It shall be created prior to application and shall be updated when required to be representative of the work being performed throughout the project.

2.2 Surface Preparation

2.2.1 Prior to abrasive blasting, perform the following:

- Examine the surface for the presence of any materials such as existing coatings or heavy corrosion that will require removal.
- If any such materials are present, and cannot be removed by abrasive blasting, conduct a pre-blast surface cleaning.
- After removal, inspect the surface again to ensure that any material remaining may be readily removed during abrasive blasting.

2.2.2 Monitor and record ambient conditions as follows:

- Measure the surface temperature, dew point, and relative humidity at the beginning of each shift and every four hours thereafter. If ambient conditions change, additional measurements shall be taken.
- Maintain a dry surface and a surface temperature of at least 3° C (5° F) above the dew point temperature (do not exceed 150°C (302°F)).
- Adhere to the Manufacturer's recommendations for surface temperature from abrasive blast cleaning until the coating cures.

2.2.3 Ensure surfaces to be abrasive blast-cleaned are free of oil, grease, slivers, mud, soils, rough welds, burrs, weld spatter, etc. Solvent clean any oil, grease, or other foreign material in accordance with SSPC-SP-1.

2.2.4 Verify that the surfaces do not contain detrimental levels of non-visible soluble salt contamination. Do not perform any coating until the surface is cleaned to a chloride level less than or equal to 20 mg/m² or 3 ppm. Test the blast-cleaned surface. Salt testing prior to blast cleaning is not required but should be performed to facilitate salt removal by distilled water washing in case the presence of salt is discovered. Salt testing frequencies are listed in Section 2.14 of this Specification.

2.2.5 Protect machined surfaces, moving parts, the edge of weld bevels, internal surfaces, and raised faces of flanges from damage during abrasive blast cleaning and coating application. Prevent blast media and coating material from entering the valves, fittings, and pipe. No amount of blast media in a valve, fitting, or pipe shall be acceptable.

2.2.6 Abrasive blast-clean the exterior metal surface to a near white finish SSPC-SP-10 (NACE # 2 or Sa 2 ½ per ISO 8501-1:2007 = SIS 055900) or better.

2.2.7 Edges of the existing coating shall be roughened by power sanding or by sweep blasting coating for a minimum distance of 5 cm (2 in). All roughened coating shall be coated.

2.2.8 The following abrasives are approved by the Company as they produce the angular profile required for correct coating application and contain no oil/grease or soluble salts:

- Green Diamond
- Black Beauty
- Black Magic
- Starblast XL
- Black Shot II
- Black Lightning

A Company-approved equivalent may be used. Contact the Responsible Engineer for approval of any alternative equivalent abrasives. Do not use copper-bearing abrasives and steel shot.

2.2.9 Ensure the abrasive blast media is dry, has a neutral pH, and contains no contaminants injurious to the performance of the paint.

2.2.10 If Company approved abrasives are used, soluble salt or oil contamination testing on the abrasive is not required providing they are packaged and stored in accordance with the Manufacturer's recommendations.

2.2.11 If an alternative equivalent abrasive is used, conduct soluble salt or oil contamination testing daily. If the Company's onsite Coating Inspector suspects the abrasive being used is contaminated or is not listed in the approved abrasive list, testing of the abrasive is required.

2.2.12 Test bulk orders of abrasive once per load to confirm that each shipment of abrasive does not contain soluble salts or oil contamination. The chloride content during testing shall not exceed 3 ppm (3 mg/L) and no oil shall be present when visually examined after remaining in the distilled water for 30 minutes. Contact the Responsible Engineer for the testing procedure if required

2.2.13 Material for abrasive cleaning shall produce an angular surface profile as indicated in Table 2-1. If higher profiles are achieved, contact the Responsible Engineer to determine acceptance.

2.2.14 Measure and record the anchor profile using replica tape and a spring micrometer in accordance with NACE RP0287. Ensure the frequency and number of readings in accordance with Section 2.13.

2.2.15 Sweep blast metal areas that develop flash rust due to exposure to rain, moisture, or humidity to return them to their original abrasive blast-cleaned condition. Coat the blasted surface immediately.

2.2.16 Ensure the compressed air supply used for abrasive blast cleaning or conventional spraying is free of water and oil. Use separators and filters on the compressed air supply to ensure that contaminants such as oil and water do not contaminate the steel surface. Perform a blotter test in accordance with ASTM D4285 at the start of every working day to verify the cleanliness of the compressed air.

2.2.17 Retest any abrasive blasting unit or compressed air used for conventional spraying that fails testing. If the second test fails, take the unit out of service until the unit is repaired and can pass the blotter test.

2.2.18 Remove residual abrasive blast products from the entire abrasive blasted surface. Use one of the following methods:

- Dry and clean bristle brush
- Vacuum
- Dry and clean compressed air.

2.3 Approved Coating Materials

2.3.1 Refer to Table 2-1 for Company-approved external liquid coatings.

Note: Order materials in spray grade or brush grade, as required.

Table 2-1: Approved Coating Materials

Coating Manufacturer	Coating Product	Max. Operating Temperature	Service	Surface Profile	Dry Film Thickness (DFT)
Denso	7200*	90°C (195°F)	Non-abrasive conditions	65 to 115 µm (2.5 to 4.5 mils)	510 to 890 µm (20 to 35 mils)+
			Abrasive conditions		1020 to 1780 µm (40 to 70 mils)
3M	327	90°C (195°F)	Non-abrasive conditions	65 to 115 µm (2.5 to 4.5 mils)	510 to 890 µm (20 to 35 mils)+
			Abrasive conditions		1020 to 1780 µm (40 to 70 mils)
Specialty Polymer Coatings	2888 RG	90°C (195°F)	Non-abrasive conditions	65 to 115 µm (2.5 to 4.5 mils)	510 to 890 µm (20 to 35 mils)+
			Abrasive conditions		1020 to 1780 µm (40 to 70 mils)
Specialty Polymer Coatings	3888	90°C (195°F)	Non-abrasive conditions	65 to 115 µm (2.5 to 4.5 mils)	510 to 890 µm (20 to 35 mils)+
Specialty Polymer Coatings	6888	90°C (195°F)	Non-abrasive conditions	65 to 115 µm (2.5 to 4.5 mils)	510 to 890 µm (20 to 35 mils)+
			Abrasive conditions		1020 to 1780 µm (40 to 70 mils)
Specialty Polymer Coatings	8888	130°C (265°F)	Non-abrasive conditions	65 to 115 µm (2.5 to 4.5 mils)	510 to 890 µm (20 to 35 mils)+
			Abrasive conditions		1020 to 1780 µm (40 to 70 mils)

Notes:
* Spray product available in Canada as Denso Protal 7250.
\+ If the Applicator decides to apply higher film thicknesses, a maximum DFT of 1,780 µm (70 mils) is allowed at no extra cost to the Company.

2.3.2 No alternative materials are acceptable.

2.3.3 Do not add solvents to the liquid coating system.

2.3.4 Coating material shall be identified with the following:

- Manufacturer's name

- Product description
- Batch number
- Date of manufacture or expiry date

2.3.5 Coating materials shall be handled, stored, and within their shelf life in accordance with the Manufacturer's recommendations at all times.

2.3.6 Spray-applied coating shall be plural component airless spray applied using a Hydra-Cat (or Company approved equivalent) and necessary ancillary equipment in accordance with the Manufacturer's recommended practice.

2.3.7 The approved materials in this Specification do not address sweating pipe conditions or flowing pipe below 10ºC (50ºF). Contact the Responsible Engineer for the approved list of materials for use in these conditions.

2.4 Preheating–General

2.4.1 Maintain the surface temperature of the substrate within the Manufacturer's recommended range from abrasive blasting through coating cure. If that range will not be available from ambient conditions, use preheating. Preheating may also be used to accelerate cure when there are time or weather constraints.

2.4.2 Preheating or accelerated curing require Company approval if not outlined in Sections 2.5 and 2.6.

2.5 Preheating—Brush and Automated Spray Preheat

2.5.1 In subzero temperatures, ensure that all snow, ice, or moisture is removed from the substrate prior to abrasive blasting. Preheating before abrasive blasting is not required if snow, ice, or moisture are not present and the steel substrate temperature is 3C° (5F°) above the dew point temperature.

2.5.2 Where direct flame is applied, abrasive blast-clean the surface, in accordance with this Specification.

2.5.3 Measure the pipe surface temperature using a contact surface thermometer.

2.5.4 Ensure preheating does not damage the mainline coating or the coating being repaired.

2.5.5 For girth weld coating perform the following:

- Preheat the surface if the pipe surface temperature is below 10˚C (50°F).
- Raise the surface temperature so that coating application takes place when the pipe surface is at or above the minimum temperature as specified. Do not apply direct flame to the pipe after blast cleaning.
- If heating is required after blast cleaning, and up until a full cure is achieved, use induction coils, infrared, or indirect heat to either maintain the surface above 10°C (50°F) or accelerate cure.

2.6 Preheating—Plural Component Spray Preheat

2.6.1 Shop Application: Carry out preheating or post curing only by increasing the ambient air temperature of the shop.

2.6.2 New Field Construction: Carry out preheating or post curing only by increasing the ambient air temperature with the use of hording and forced air heaters.

2.6.3 In-Service Facilities: Preheating should not be attempted. Ambient heating can take place prior to the coating operation provided the increase in temperature does not cause the pipe to sweat. Ambient heating can only be used if the flowing line temperature is below 10°C (50°F), with the substrate being a minimum of 3ºC (5ºF) above the dew point. It is recommended that coating application take place without ambient heating. Once the coating application is complete, start forced air heating, to increase the ambient air temperature within the hording, to post cure the coating.

Note: Post curing in New Field Construction and In-Service Facilities may lead to the formation of amine blush on the exterior surface of the applied coating. Do not conduct repairs until the amine blush has been removed in accordance with Section 2.11 of this Specification.

2.7 Coating Application—General

2.7.1 Follow Manufacturer's recommendation for acceptable substrate temperature range for coating application.

2.7.2 Overlap existing coating by a minimum distance of 5 cm (2 in.). Ensure feathered and roughened areas of existing coating are completely covered by the overlap.

2.7.3 Ensure finished coating is generally smooth and free of application defects (e.g., pinholes, fish eyes, sags, and holidays). Excessive drips, running, sagging, or other discontinuities shall be cause for rejection.

2.7.4 The Dry Film Thickness of the cured coating shall be as outlined in Table 2-1.

2.7.5 There is no restriction to pipe length for hand coating. The Project is responsible for deciding the application method chosen for the project.

2.7.6 Line pipe coated in accordance with this Specification may be used for operations such as horizontal directional drills and road bores. This coating shall not be cold bend in the field. If field bending is required, obtain Company approval prior to bending.

2.7.7 Handling or backfilling is not permitted until the coating cures, as determined by the Company's onsite Coating Inspector. Cure may be accelerated by post heating. Post heat only by an indirect method such as induction, ambient temperature, or infrared. Direct flame is permissible for tie-in welds but take care to ensure the coating does not char or burn. Do not touch the newly applied coating with the flame. The post heat temperature of the coating surface should not exceed the Manufacturer's recommended application temperatures.

2.7.8 Coating shall be holiday inspected as per section 2.18.

2.7.9 Coating shall be tested for adhesion as per section 2.17.

2.7.10 Coating shall be tested for cure as per section 2.16.

2.8 Coating Application—Plural Component Spray

2.8.1 Brush grade liquid coating material may be used to stripe-coat hard to spray areas, sharp edges and repairs. Ensure stripe coat is within recoat window, if not the stripe coat shall be abraded prior to the spray application.

2.8.2 Measure the wet film thickness (WFT) of the applied coating using a wet film gauge and consider the following:

- Brush out or spray over any marks.
- Take wet film measurements on every component (e.g., joint, elbow, tee, and piping) being coated.
- Apply additional coating if low areas are detected before tack-free condition occurs.

2.9 Coating Application—Automated Spray Application

2.9.1 Do no override any warning alarms produced by the monitoring system for the automated application unit unless it is in the system requirements and is stated in the ITP. Inform the Company's onsite Coating Inspector of warning alarms or system upsets in a timely manner.

2.9.2 Be cautious to prevent overspray of the coating material. Consider the following:

- Use welding shacks as enclosure structures to prevent overspray.
- If welding shacks are not available, then an approved alternative may be used.
- Submit details around the alternate enclosure to the Company's onsite Coating Inspector or Responsible Engineer for review and approval. The Company's onsite Coating Inspector or Responsible Engineer shall provide written acceptance of the alternate structure deeming it suitable for use.

2.9.3 Replace the spray tip every 50 km or 4000 applications, whichever comes first, regardless of acceptable visual performance. Replace the spray tip immediately if it fails the visual performance test.

2.9.4 Provide downloadable data acquisition application parameters to the Contractor and the Company's onsite Coating Inspector daily for review.

2.10 Coating Repairs—General

2.10.1 In general, use the same material for repairs as the parent coating. Use a brush grade material to repair a spray grade parent coating where applicable.

2.10.2 Repair FBE corrosion coating (System 1A), and FBE corrosion coating with FBE abrasion coating (System 2B), with a suitable liquid coating material selected from the materials listed in Section 2.3. Inspect System 1A and 2B coatings in the field and repair any damage found (e.g., scratches, scrapes, and gouges). At the discretion of the Company's onsite Coating Inspector, repair any visual imperfections that could shorten the longevity of the plant-applied or newly applied coating systems, even if a holiday has not been detected.

2.10.3 Mark and repair any coating damage (e.g., scrapes and gouges) that have disrupted or reduced the coating film thickness to less than the specified thickness. Report the damage to the Responsible Engineer if gouges in the coating extend to the steel substrate and if damage to the steel seems to have occurred. Only repair the coating damage after the condition of the steel has been assessed and approval has been given by the Responsible Engineer.

2.10.4 Ensure repairs to coatings are in accordance with the requirements below:

- Small repairs: For repairs up to 2 mm (1/16 in.) in diameter, roughen the surface of the parent coating to remove gloss around the holiday to a distance of at least 25 mm (1 in.). Use 80 to 120 grit sandpaper or light sweep blasting.
- Medium sized repairs: For repairs up to 25 cm^2 (4 in^2) in area, prepare surface by abrasive blasting or by power tool cleaning in accordance with SSPC-SP 11 to remove dirt, scale, rust, damaged coating, and other foreign material (to a bare metal condition), and to retain or produce the surface profile required. During power tool cleaning, maintain the original profile depth if possible. Repair areas prepared with either method shall be monitored and be in accordance with this Specification.
- Large repairs: Surfaces of repair areas exceeding 25 cm^2 (4 in^2) shall be prepared by abrasive blast cleaning.

2.10.5 Roughen the adjacent parent coating and any holidays or damaged coating adjacent to the cutback area (e.g., welding band leg damage) for at least 25 mm (1 in.) around the repair and feather the edges.

2.10.6 After abrading, remove all dust from the prepared areas using compressed air, a clean, dry bristle brush, a clean, dry, lint-free cloth, or in accordance with SSPC-SP-1 using acetone, xylene, MEK, or any other solvent approved by the Manufacturer.

2.10.7 Cover the defect area entirely with the coating repair material and overlap the parent coating by a minimum of 25 mm (1 in.). Apply the repair material in accordance with Section 2.7.

2.10.8 Overcoating of pinhole, holidays, and repairs shall not exceed a total DFT of 1,270 µm (70 mils) for a 150 mm (6 in.) radius around the holiday.

2.10.9 Preheat the surface to be recoated when the surface temperature is below the minimum required by the Manufacturer.

2.10.10 Depending on the application type, various methods may be used to preheat or post heat to accelerate the cure of small and medium sized repairs. The Applicator shall inform the Company's onsite Coating Inspector, in writing, as to the proposed method. The Company's onsite Coating Inspector will review to ensure that the method does not damage the coating or contaminate the steel.

2.11 Coating Repairs—Overcoating Existing Coatings

2.11.1 Inspect the surface to be overcoated as follows:

- Confirm the surface is not contaminated with amine blush, oil, grease, or other contaminants. Do not overcoat the contaminated areas if amine blush or other contamination is suspected.
- Solvent-wash the contamination in accordance with SSPC-SP1 solvent cleaning prior to surface preparation.
- If the contamination cannot be removed, strip and reapply the coating.

Note: Epoxies develop amine blush during curing when exposed to water (e.g., rain), cool or humid conditions, or ambient air containing high levels of carbon dioxide. Liquid coatings that develop amine blush have a duller gloss, versus a liquid coating that has cured properly, and are slightly tacky to the touch.

2.11.2 Liquid coatings are permissible on full lengths of piping for abrasive conditions (e.g., HDDs and road bores). Apply liquid coatings directly to bare steel or over existing FBE System 1A coated pipe.

2.11.3 The Company's preferred method is FBE abrasion resistant coatings applied in accordance with TES-COAT-FBE (EDMS No. 3670892). However, the Project may approve liquid coatings. Spray application is the preferred application method of abrasion resistant coatings. However, the Project may choose to conduct the application by hand when required. Applications may take place in the shop or the field.

2.11.4 Roughen FBE System 1A coated pipe by sweep blasting to remove gloss and provide a minimum anchor profile of 13 to 38 µm (0.5 to 1.5 mils).

2.11.5 Upon completion of the surface preparation, conduct a DFT survey to establish the remaining average FBE coating thickness.

2.11.6 All coated surfaces shall have a minimum total DFT of 1020µm (40 mils) comprising the measured average FBE thickness and the applied abrasion resistant coating material. The maximum total DFT shall be 1780 µm (70 mils) comprising the measured average FBE thickness and the applied ABR coating material.

2.11.7 All listed products in Table 2-1 are acceptable for use as an overcoating for existing FBE System 1A and direct to bare steel pipe for abrasive conditions.

2.12 Inspection and Testing—General

2.12.1 The Applicator's Inspector shall be on site during surface preparation and coating application.

2.12.2 The Applicator shall be responsible for the quality of all their operations.

2.12.3 The Applicator shall provide calibrated test instruments to the Company's onsite Coating Inspector for verification. Calibrate all test instruments on a yearly basis.

2.12.4 Carry out and record all quality control measurements and inspections on a Company-approved form that captures required data. Ensure the records outlined in Table 2-2 are available for review by the Company at all times and submit originals to the Company at the end of the project.

Table 2-2: Required Physical Testing

Test Type	Test Reference	Frequency
Environmental Conditions & Steel Surface Temperature	See Section 2.2.2	Start of shift and every 4 hours thereafter (minimum) per crew
Visual Inspection of Steel Surfaces for Contaminants	See Section 2.2.1 and 2.2.3	100% of all items to be coated
Abrasive Contamination Testing (as applicable)	Contact Responsible Engineer	See Section 2.2.8 - 2.2.12
Abrasive Blast Air Blotter Test	ASTM D4285 & Section 2.2.16	Beginning of each shift
Salt Contamination of the Steel Surface	SSPC-Guide 15 & Sections 2.2.4, 2.14 20mg/m² or 3ppm	1 per 50 Joints for mainline, 1 per 5 joints for tie-in crew. To be conducted by each crew (tie-in and mainline)
Visual Exam of Cleaned Steel Surfaces	SSPC VIS 1 and Section 2.2.6	100% of all cleaned surfaces for coating
Abrasive Blast Profile Measurements	ASTM D4417	See Section 2.13
Monitor Steel Preheat (if required)	Pre-Heat Section 2.4	100% of items coated
DFT	Gauge Readings	See Table 2-1 and Section 2.15
Visual Inspection of Application	See Section 2.7.3	100% of items coated
Holiday Detection	NACE SP0188 & Table 2-5	100% of items coated
Cure Test Using Shore D Hardness Conducted on the Steel and Existing Coating	See Section 2.16	1 set per 25 joints or minimum 1 per day whichever is greater (maximum of 10 hours) it shall be conducted by each crew (Tie-in and mainline) Shop – 2 per shift (maximum of 10 hours)
Adhesion Test Using X-Cut Conducted on the Steel and Existing Coating	See Section 2.17	1 set per 50 joints or minimum 1 per day whichever is greater (maximum of 10 hours) to be conducted by each crew (tie-in and mainline) Shop – 2 per shift (maximum of 10 hours)

2.13 Inspection and Testing—Anchor Profile Measurement Frequency

2.13.1 When cleaning single items, conduct the minimum number of readings listed within Table 2-3.

2.13.2 If a trailer load or large shipment of piping, fittings, valves, pipe supports, or multiple pre-fabricated assemblies are to be abrasively cleaned for coating, at the discretion of the Company's onsite Coating Inspector the frequency of profile measurements listed may be changed to four measurements per hour of abrasive blasting. Take blast profile readings at different locations on the items abrasively cleaned. If this process occurs, document it on the Company approved form.

Table 2-3: Profile Measurement Recordings

Object	Size	Minimum Number of Spot Readings
Pipe	Every 20 linear meters (65 ft.)	4 randomly spaced along and around the pipe
Fittings	Each, less than 20 linear meters (65 ft.)	4 randomly spaced along and around the fitting
Pipe Sections	Each, less than 20 linear meters (65 ft.)	4 randomly spaced along and around the pipe section
Girth Welds and Tie-in Welds	1 set of 3 readings per 25 joints	3 per joint in different quadrants of the girth weld or tie-in weld
Valves	Each	3 along and around the valve for ≥ 406 mm (16 in.) 2 along and around the valve for < 406 mm (16 in.)
Pre-Fabricated Valve Assemblies (all sizes)	Each Assembly	6 randomly spaced along and around the assembly for ≥ 406 mm (16 in.) 4 randomly spaced along and around the assembly for < 406 mm (16 in.)
Repair Areas	Surfaces of repair areas exceeding 25 cm^2 (4 $in.^2$)	1 reading every 2nd repair area

2.14 Inspection and Testing—Salt Testing Frequency

2.14.1 Testing frequencies for non-soluble salt on steel surfaces for new construction or fabrication shall be as follows:

- Line-pipe–test the first three joints at the start of the project, then once every 3 km (1.4 miles). If salt is present, test every joint until at least 10 consecutive joints are salt-free.
- Tie-ins–test the first weld and 25th welds. If no salt is present, no further testing is required unless the Company's onsite Coating Inspector suspects salt contamination or the mainline coating tests positive for salt contamination during production. If salt is present on tie-ins, test every weld until five consecutive tie-in welds are salt free. This is on a per crew basis.
- All other items (e.g., valves, fittings, risers)–test once per item. If a truckload of valves, fittings or assemblies require testing, test twice per truckload.

2.15 Inspection and Testing—DFT Measurement

2.15.1 Measure the DFT with a calibrated thickness gauge. Verify calibration of the gauge at the beginning of the shift or every 10 hrs (whichever comes first) to the National Institute of Standards and Technology (NIST) Certified Coating Thickness Standard, or gauge Manufacturer supplied shims.

2.15.2 After the coating has cured to a tack-free condition, measure, at random, the DFT of each valve, fitting, and pipe section as in accordance with Table 2-4.

Table 2-4: DFT Measurements Required

Object	Size	Minimum Number of Spot Readings
Pipe	Every 20 linear meters (65 ft.)	5 randomly spaced along and around the pipe
Fittings	Each, less than 20 linear meters (65 ft.)	5 randomly spaced along and around the fitting
Pipe Sections	Each, less than 20 linear meters (65 ft.)	5 randomly spaced along and around the pipe section
Girth Welds and Tie-in Welds	Each	5 randomly spaced along and around the girth weld or tie-in weld
Valves	Each	4 along and around the valve for ≥ 406 mm (16 in.) 2 along and around the valve for < 406 mm (16 in.)

2.15.3 Use the following criteria when DFT readings are outside of the range specified in each application procedure:

- If one out of five DFT readings is outside of the range specified, perform further testing. The Company may have their onsite Coating Inspector mark with a felt pen a 30 cm x 30 cm (12 in. x 12 in.) area of their choice on the pipe. The Inspector will take 20 random DFT measurements within the marked area. No individual reading shall be less than the specified minimum thickness.
- If coating thickness is below specified DFT, additional coating application must be within the Manufacturer's recoat window. If the sum total of the areas is less than 1 m^2 (1550 in^2) per item coated, sweep blasting and overcoating may be performed. Deviations require written acceptance from the Responsible Engineer.
- If coating thickness is greater than specified DFT, do not abrade the coating to reduce the thickness to the specified thickness. Remove the coating and recoat.

2.16 Inspection and Testing – Cure Test Using Shore D Hardness

2.16.1 The Contractor's Coating Inspector and/or the Company's onsite Coating Inspector shall conduct this test on girth welds, tie-in welds, pipe, or pipe assemblies. Note: for shop spray applications, it is acceptable that Shore D testing can be conducted on panels that are prepared, applied and cured in the same manner as the items coated during production.

2.16.2 Conduct the Shore D test when the coating has completely cured as determined by the Applicator's Coating Inspector. Conduct testing as follows:

- Start out at a spot where the coating DFT is measured at 765µm (30 mils) minimum.
- Test between 10°C and 25°C (50°F and 77°F) after the coating has reached a thumbnail hard state. Coating is sufficiently cured for handling or backfilling if a minimum Shore D hardness rating of 80 is obtained.
- If Shore D hardness is measured on the overlap area, the total thickness of the coating shall be at least 765µm (30 mils) greater than the thickness of the underlying overlapped coating.
- Frequency of testing is in accordance with Table 2-2.

  Note: For projects in hotter geographical locations or warmer summer ambient temperatures, the target range of 10 to 25°C for Shore D testing may not be achievable. Contact the Responsible Coatings Engineer for guidance.

2.17 Inspection and Testing—Adhesion Test Using X-cut

2.17.1 Conduct X-cut adhesion testing on coating applied to the steel surface and on the overlap area between existing and newly applied coatings (e.g., liquid epoxy overlapping onto FBE coated line pipe). The Contractor's Coating Inspector and/or the Company's onsite Coating Inspector shall conduct this test on girth welds, tie-in welds, pipe, or pipe assemblies. Note: for shop spray applications, it is acceptable that X-cut adhesion testing can be conducted on panels that are prepared, applied and cured in the same manner as the items coated during production.

2.17.2 Conduct the X-cut adhesion test when the coating has completely cured as determined by the Applicator's Coating Inspector. Conduct testing as follows:

- Test when the exterior coating temperature is between 10°C and 25°C (50°F and 95°F) after the coating is considered cured.
- Frequency of testing is in accordance with Table 2-2.

Note: For projects in hotter geographical locations or warmer summer ambient temperatures, the target range of 10 to 25°C for X-cut adhesion testing may not be achievable. Contact the Responsible Coatings Engineer for guidance.

2.18 Inspection and Testing—Holiday Detection

2.18.1 Carry out holiday detection in accordance with NACE SP0188. Set voltages as described in Table 2-5. Calculate voltages based on the average coating DFT.

Table 2-5: Required Holiday Detection Voltage Ranges

Coated Item	Calculation Formula	Holiday Detection Voltage (VDC)
Girth Welds & Tie-In Welds	4 V/µm (100 V/mil)	2,000 – 7,000
Abrasion Resistant (ABR) Girth Welds	4 V/µm (100 V/mil)	4,000 – 7,000
Abrasion Resistant Overcoated Pipe with Liquid Coating	4 V/µm (100 V/mil)	4,000 – 7,000
Fusion Bonded Epoxy FBE System 1A	5 V/µm (125 V/mil)	2,000 – 5,000
Fusion Bonded Epoxy FBE ABR System 2B	5 V/µm (125 V/mil)	4,300 – 5,000
Repairs to FBE or liquid applied coatings	4 V/µm (100V/mil)	2,000 – 7,000

2.18.2 Inspect completed coating repairs for holidays as specified in Table 2-5.

2.18.3 Use a spring encirclement or half-moon type search electrode to holiday detect pipe sections. Holiday detect girth welds with spring encirclement or a brass brush electrode. To ensure that no holidays are missed, bring the spring encirclement electrode back to the downstream side of the toe of the weld inspected. Use a brass brush electrode to reach the bottom of corrosion pits.

2.18.4 Calibrate holiday detectors using a calibrated voltmeter at the start of the working day and at least every four hours or as specified by the Company.

2.18.5 Keep calibration certifications for the holiday detection equipment and voltmeter with the equipment.

2.18.6 At the discretion of the Company, make an intentional holiday in the coating to bare steel to verify that the holiday is detected at the appropriate voltage for the coating application. If the voltage is not adequate, increase the voltage until the intentional holiday is detected, but do not exceed 7,000V.

2.18.7 Keep the coating surface dry and free of deposits (e.g., soil, ice, snow, or tape) when holiday testing is conducted. Markings on the coating surface having no measurable thickness are allowed when holiday testing.

2.18.8 A low voltage (60 to 70V) wet sponge holiday detector may be used on nuts and bolts and areas difficult to access. Do not damage adjacent coating with a lower DFT.

2.18.9 Do not attempt inspection with a holiday detector until the coating is hard dry (hard dry as determined when the coating does not indent when pressed with a thumbnail).

3 VARIANCES

Any deviation shall follow the TransCanada Management of Change (MOC) Variance Procedure (EDMS No. 7728702). External vendors must contact the TransCanada Project Engineer for variance approval.

4 ROLES AND RESPONSIBILITIES

Table 4-1 below outlines the roles and responsibilities required for the use of this Specification.

Table 4-1: Roles and Responsibilities

Role	Responsibilities
Applicator	The Applicator is responsible for ensuring: • The proper method is used to apply the appropriate coating materials to the appropriate surface area.
Coating Inspector	The Coating Inspector is responsible for ensuring: • That the Applicator uses the proper method to apply the coating materials to the appropriate surface area, and that the result meets the standards set forth by the Company in this specification.
Responsible Engineer	The Responsible Engineer is accountable for ensuring: • That the plan set forth by the applicator meets the standards set forth by the Company, and that resolution to any questions that arise from the use of this specification meet the standards set forth by the Company.
Manufacturer	The Manufacturer is responsible for ensuring: • That the product produced for application is produced in accordance with the documentation that it provides to the Applicator.

5 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are detailed below in Table 5-1. Use the latest document revision, unless otherwise approved by TransCanada.

Table 5-1: External and Internal References

Document No.	Title
Legal Requirements	
For this Specification, there are no specific legal requirements.	
Industry Codes and Standards	
CSA Z245.30	Field-applied external coatings for steel pipeline systems (Canada only)
ISO 9001	International Standards Organization - Quality Management Standard Certifications
NACE SP0188	Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
SSPC SP-1	Solvent Cleaning

Document No.	Title
SSPC SP-10	NACE No. 2/SSPC-SP 10, Near-White Metal Blast Cleaning
ASTM D4285	Standard Test Method for Indicating Oil or Water in Compressed Air
Internal References – Documents Referenced by this Specification	
EDMS No. 3670892	TES-COAT-FBE External Fusion Bond Epoxy for Steel Pipe Specification (CDN-US-MEX)
EDMS No. 7756	TES-COAT-PET Application of Petrolatum Tape Coating Specification (CDN-US-MEX)

6 DOCUMENTATION AND RECORDKEEPING

All project documentation is held in the project file and stored in accordance with the Company's guidelines.

7 DOCUMENT HISTORY

Rev.		
13	**Description**	**Effective Date**
	This document is the new version of TES-COAT-EPU, updated in accordance with the documentation Streamlining initiative.	2016-Nov-08
	Rationale Statement	**Responsible Engineer**
	of content to reflect the updated document collection of the coatings This document was developed / revised in order to address the following requirements: • Streamlining department	Aissa Van Der Veen P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Coatings group and to make it more easily accessible to those who use it.	Aissa Van Der Veen P. Eng.

8 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
Update to format and content	Part of Streamlining and Simplification process, document has been reformatted and updated to reflect TransCanada template

9 APPROVALS

APPROVALS		
Originator: Aissa Van Der Veen, P. Eng. Welding and Materials Engineering	Signature	Nov. 8, 2016 Date
Reviewer: Niteesha Falcon, P. Eng. Welding and Materials Engineering	Niteesha Falcon Signature	Nov 8, 2016 Date
Responsible Engineer: Aissa Van Der Veen, P. Eng. Welding and Materials Engineering	Signature Nov. 8, 2016 Date	PROFESSIONAL ENGINEER ALBERTA AISSA VAN DER VEEN APEGA Permit to Practice P7100

APPENDIX A INSTRUCTIONS FOR ITEMS TO BE COATED

A-1 COATING OF VALVES AND FITTINGS

A-1-1 The coating material for valves and fittings shall be spray grade liquid coating in accordance with this Specification. Use brush grade liquid coating on difficult areas.

A-1-2 The crotch area, including the outlet portion, of all tees with a nominal run diameter greater than NPS 16 and run diameter to outlet diameter ratio in excess of 0.6 shall not be coated with any liquid coatings until after secondary hydrostatic testing has been completed to avoid cracking of the coating. Coating applications may proceed prior to secondary hydrostatic testing providing the items remain exposed (not backfilled), so the coating can be inspected after the secondary hydrostatic test for cracking and disbondment from the steel surface. The Applicator shall check with the Project to determine if any items to be coated shall be left bare until after secondary hydrostatic testing due to commitments to regulatory bodies.

A-1-3 Do not apply direct heat to the valve assembly during coating. It is recommended that valves be coated in an enclosure or indoors. Maintain a minimum surface temperature of 10°C (50°F) until four hours after the coating is tack free.

A-1-4 Valves may not be post heated except by increasing ambient air temperature.

A-1-5 The coating cutback on liquid coating applied to new piping shall be 10.5 cm (4 in.), unless specified elsewhere (e.g., purchase order).

A-2 COATING OF GIRTH WELDS

A-2-1 Coating material for girth welds shall be brush grade and shall be applied according to this Specification. The use of spray grade coating material for girth welds may be permitted when applied by automated spray systems. Hand-held spray is not permitted for girth weld coating.

A-3 COATING OF STRUCTURAL STEEL

A-3-1 The coating material for structural steel to be buried, such as below ground pipe supports, shall be spray or brush grade and shall be applied according to this Specification. Piles do not require below ground coating (above grade piles do require painting as per TES-COAT-P1). Any below ground pipe supports fabricated or installed in the field shall be entirely coated (tops, sides and bottom). The pipe supports shall be coated with an approved material listed in Table 2-1 of this Specification. Holiday testing of structural steel is not required.

APPENDIX B CSA Z245.30-14 REQUIREMENTS (CANADIAN PROJECTS)

This Company Specification shall comply with the requirements of Canadian Standards Association (CSA) Standard Z662 and CSA Z245.30-14 and any amendment, supplement, or errata issued by CSA for use on projects in Canada.

The coating, application process, and resulting coating system shall meet the requirements of CSA Z245.30-14, this Specification (and its associated applications procedures), and the Manufacturer's Qualified Application Procedure (MQAP). Use this Specification for Canadian projects in conjunction with CSA Z662 and CSA Z245.30-14 and any amendment, supplement, or errata issued by CSA. The numbering of Clauses in this Appendix corresponds to the numbering in CSA Z245.30-14. Clauses in this Appendix that are in addition to CSA Z245.30-14 are numbered sequentially.

The Manufacturer's MQAP for the use of their product shall be considered an integral part of this Specification. A list of all Company approved MQAPs is available through the Responsible Engineer. Only MQAPs on this list shall be used for coating systems listed in CSA Z245.30 defined as FC1, FC2 and FC3.

Note: In the event of a conflict between the Manufacturer's recommendations and this Specification, this Specification shall prevail. In this Specification and Appendices, when a Company Specification or Procedure is listed, it is implied that the application shall be in accordance with the MQAP and the listed Company Specification.

2 Reference publications

The applicator shall gather all reference documents listed in CSA Z245.30-14 and the reference documents listed in this specification on site where the coating application is taking place and be available to the Company onsite Coating Inspector for review and acceptance.

5 Materials

5.1 Product ordering

5.1.3 All Manufacturer and Company approved coating MQAPs are available through the Responsible Engineer. The MQAP to be applied shall be added to the purchase order.

5.2 General

a)The Applicator shall request the certificate of material qualification from the Manufacturer for each shipment of coating received on site or at a shop location. This certificate shall be added to the turnover package.

5.3 Qualification

5.3.4.1 The Manufacturer shall inform the Company Responsible Engineer when there is a change in one or more of the following:

a) The coating chemical formulation;

b) The location of manufacture;

c) The manufacturing process; and

d) The application procedure (MQAP)

6 Coating application

6.1.2 Qualification of applicators

6.1.2.1 h) The Manufacturer shall be present during applicator training of the MQAP prior to start of work, unless a train-the-trainer program has been approved by the Company.

6.1.2.3 The Applicator shall inform the Company when all aspects of Applicator training and qualification testing are being conducted. The Company's onsite Coating Inspector shall make all attempts to witness the training and qualification testing.

6.1.2.5 Certificate of applicator qualification

Copies of all certificates of Applicator qualification shall be provided to the Company's onsite Coating Inspector.

6.1.3.2 Experience logs

Applicator's experience logs shall be reviewed by the Company's onsite Coating Inspector to ensure the Applicator is qualified to the MQAP being used on the project.

6.1.3.3 Competency determination

6.1.3.3.3 The Company shall review the Application company's competency determination and make its own determination based on the requirements of Clause 6.1.3.3.1.

6.1.3.4 Competency records

Copies of competency determination and retests shall be provided to the Company's onsite Coating Inspector.

6.2 Application practices and equipment

6.2.3 Surface temperatures

6.2.3.4 Substrate temperature and curing temperatures to be used shall be in accordance with the MQAP and TES-COAT-EPU.

6.2.4 Applying the coating system

6.2.4.1 The application of the coating shall be in accordance with the MQAP and TES-COAT-EPU.

6.3 Records

6.3.1 All quality control measurements and inspections shall be carried out and recorded by the Applicator or Company personnel on the appropriate form.

7 Inspection and testing

7.1 Inspection and test plan

j) List Specification clause numbers for each line item on the ITP where applicable.

9 Markings

9.1 The Applicator shall mark the date of application and the name of/or a unique identifier for the applicator on, or adjacent to, the applied coating.

11 Applied coating test reports and certificates of application compliance

11.1 Test reports

The Applicator's records, as outlined in Table 2-2 of this Specification and Table 6 of CSA Z45.30-14 shall be available for review by the Company at all times and copies shall be submitted to the Company's onsite Coating Inspector. The Company shall retain the original copies of the coating reports.

11.2 Certificates of application compliance

The Applicator shall provide the Company, at the end of the project, with certificates of application compliance stating the outlined items in Clause 11.2 of CSA Z245.30-14.

PURPOSE

This Specification defines the minimum requirements for the surface preparation, application of paint, repairs and inspection of paint materials for above ground gas and hazardous liquid facilities and equipment for new construction and integrity related projects for coastal and non-coastal areas.

SCOPE/APPLICABILITY

This Specification applies to all gas and hazardous liquid pipeline systems in Canada, the United States (U.S.) and Mexico, and includes facilities such as miscellaneous steelwork, piping and piping components, vessels and equipment. It applies to both shop and field work under a full range of operating conditions.

This Specification does not apply to the following items:

- battery chargers
- utility air compressors (including desiccant dryers)
- reciprocating motors/compressors
- gas turbine and driven equipment
- exhaust silencers
- start gas vent silencers
- actuators/operators and their associated equipment
- heat exchanger header boxes for engine jacket water coolers
- unit heaters
- engine jacket water coolers
- transportable oil storage tanks
- small tanks for compression and measurement
- valves NPS 14 and smaller
- concrete
- low pressure piping (< 2000 kPa) (< 290 psi)
- structural steel and piles (where a corrosion allowance has been included)

Note:

This list is not comprehensive. Contact the Responsible Engineer for a list of all items that may be painted by the Manufacturer or that may fall outside of the scope of this Specification. This list is at the discretion of the Project.

All Applicators applying above ground paint materials in accordance with this Specification shall be Company-approved Applicators.

This Specification applies to all divisions of the Company and its wholly-owned subsidiaries, and all operated entities/facilities in Canada, the United States (U.S.) and Mexico.

Within this Specification, TransCanada is referred to as the Company.

Wherein the Manufacturer's literature, governmental requirements or regulatory requirements conflict with this Specification, the more stringent requirement shall govern.

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1 GLOSSARY

Applicator

The company responsible for the actual application of the paint.

Company Coating Inspector

A designated onsite coating inspector hired by the Company for the duration of the Project.

DFT

Dry Film Thickness. The thickness of the paint after it has hardened to a solid state, as defined in The Society for Protective Coatings (SSPC)-PA 2 *Procedure for Determining Conformance to Dry Coatings Thickness*.

Manufacturer

A company that manufactures and supplies the paint system.

Pre-fabricated valve assemblies

Assemblies that have been bolted or welded together, such as pipe pups, valves, elbows, check valves and flanged items that are already fabricated prior to painting and are to be installed as one piece into the facility being constructed.

Structural steel

Steel I beams and piles, not including pipe supports or pipe saddles.

Vendor

Any outside source hired by the Company to complete work.

WFT

Wet Film Thickness. The thickness of the paint film while in the liquid state.

2 REQUIREMENTS

2.1 General Requirements

2.1.1 The Applicator is responsible to adhere to the requirements outlined in this Specification.

2.1.2 The Applicator shall have Safety Datasheets (SDS) for all controlled products and shall ensure that its employees (i.e., sub-contractors or agents) are familiar with the instructions of the SDS.

2.1.3 The SDSs shall be available on site for review by the Applicator's personnel and the Company Coating Inspector.

2.1.4 The Applicator shall provide at least one National Association of Corrosion Engineers (NACE)-certified CIP Level I at their shop or field location. This employee shall perform inspections, supervise other employees conducting inspections and be experienced and competent in the application of above ground paints. An alternatively trained employee may be considered acceptable upon review and approval by the Responsible Engineer.

2.2 General Requirements—Compliance

2.2.1 All work shall be done in accordance with the Manufacturer's recommendations, product datasheets, application procedure and this Specification.

2.2.2 All quality control measurements and inspections shall be carried out and recorded by the Application company or Company personnel.

2.2.3 For applications outside of Canada, the U.S. and Mexico, contact the Manufacturer and confirm in writing that the paint products are the same paint product listed in this Specification, as there may be changes in the Manufacturer's Technical Datasheets (TDS) between locations. Provide the information to the Company's onsite Coatings Inspector or Responsible Engineer.

2.2.4 Personal protective equipment (PPE) shall be used while abrasive blasting. This shall include proper clothing, hearing protection, safety boots, gloves and a ventilated blast hood to protect the face and prevent inhalation of abrasive blasting dust. The blast hood shall be fed with air that is pressure regulated, filtered and meets regulatory requirements.

2.2.5 Abrasive blast cleaning equipment shall be fitted with a functional dead man remote control system. Abrasive blast hose couplings shall be secured with safety wire and chokers. All mechanical equipment, including blasting equipment, shall be earthed and all precautions taken to prevent the build-up of static electricity.

2.2.6 Paints and solvents should only be used in well-ventilated areas and personnel shall wear the appropriate respiratory protection as required by the Manufacturer.

2.2.7 During paint application, no open flames, smoking, grinding or welding shall be allowed in the immediate vicinity.

2.2.8 Under no circumstances shall any paint be removed by heating with an open flame.

2.3 General Requirements—Quality

2.3.1 The Applicator shall have at least one of the following with regards to a quality program:

- a current registration as a Society for Protective Coatings (SSPC) QP 1 (Field Application to Complex Industrial and Marine Structures) and as an SSPC QP 3 (Shop Painting Certification Program)
- NACE NIICAP AS-1 *Program for Accreditation of Field and Shop Coatings Contractor* accreditation
- a certificate of compliance with International Organization for Standardization (ISO) 9001 *Quality Management Systems – Requirements*
- a documented Company Quality Management System

2.3.2 Company personnel applying paint materials shall read and understand this Specification and the TDS before commencing painting operations. Company personnel wanting to spray apply above grade paint materials shall contact the Responsible Engineer for approval.

2.3.3 An Inspection and Test Plan (ITP) for the supply and application of paint materials shall be submitted for approval to the Company Coating Inspector or Responsible Engineer prior to the commencement of work.

2.4 Materials—Paint Material Selection

2.4.1 Paint materials shall be:

- selected according to the paint system requirements outlined in APPENDIX A and APPENDIX B, based on the atmospheric zones (ISO 12944 *Paints and varnishes – Corrosion protection of steel structures by protective paint services*, corrosivity category) described in Table 2-1
- from the same Manufacturer for multi-coat systems (i.e., primer and topcoat system)

Table 2-1: ISO Corrosivity Category Based on Environment

ISO Corrosivity Category	Environment
C1 and C2	Heated buildings/neutral atmosphere, rural areas, low pollution
C3	Urban and industrial atmospheres with moderate sulphur dioxide levels, production areas with high humidity
C4	Industrial and coastal areas with moderate salinity, chemical processing plants

2.4.2 The material for each coat shall be from the same Manufacturer in multi-coat systems.

2.4.3 Each coat shall be a different colour or shade so that successive coats can be distinguished.

2.4.4 Topcoat paint options include polyurethane and polysiloxane products. The attributes of these products are detailed in Table 2-2. The Project shall decide which attributes are required.

Table 2-2: Topcoat Appearance Attributes

Material	Pros	Cons	Suggested Use
Polysiloxanes	• Better gloss retention • Longer lasting colours	• More expensive than Polyurethanes • Longer cure times	• Facilities in high traffic areas may choose the polysiloxane finish due to high visibility
Polyurethanes	• Less expensive than Polysiloxanes • Quality of the paint system and the facility's integrity is not compromised by faded colours • Cures faster, better shop output of completed items	• Colours fade more quickly	• Facilities located in remote areas may choose the polyurethane option due to low visibility

2.4.5 Alternative materials may be considered if approved in advance by the Responsible Engineer. The proposed Manufacturer's TDS and all testing data performed on the paint product (Manufacturer or third party testing results) shall be included in the request for approval.

2.4.6 For bolts and pipe saddles, electroless nickel coating (ENC) may be used as an alternative material. The ENC may be painted if required. Contact the Responsible Engineer if the ENC is to be used.

2.5 Materials—Packaging and Storage

2.5.1 Paint materials shall be delivered to the Applicator in the Manufacturer's unopened, original containers and stored in accordance with the Manufacturer's latest published instructions.

2.5.2 Paint materials shall be applied within their recommended shelf life, otherwise re-certification shall be obtained from the Manufacturer in writing.

2.5.3 Containers of paint or components shall only be opened if they will be used immediately.

2.5.4 Containers shall be identified with the Manufacturer's name, product description, batch number, date of manufacture and expiry date.

2.6 Application—Surface Preparation

2.6.1 All nearby equipment and machinery shall be protected from abrasives, dust and overspray. The following surfaces are not to be painted unless otherwise specified by the Project, and must be protected while blasting and painting (spraying) other surfaces:

- machined surfaces such as flange faces
- Manufacturer’s name and data plates
- brick, masonry or concrete
- exposed stainless steel (including stainless steel valves), copper, brass and aluminum
- galvanized surfaces
- glass, porcelain and plastics
- valve stems, glands, control valve positioners and gauges
- aluminum sheathing over insulation and weatherproofing
- switchgear, motor control centers and transformers
- items that have a special finish applied by the Manufacturer (e.g., gas engines, generators, compressors, etc.)

2.6.2 If the Applicator is unsure whether an item is to be blasted or painted, the Applicator shall request clarification from the Company Coating Inspector before proceeding with surface preparation activities.

2.6.3 For field applications, the pipe shall be heated to remove any forms of moisture (e.g., ice, snow, wet surfaces, etc.) before surface preparation activities commence.

2.6.4 Prior to abrasive cleaning steel surfaces, all visible burrs, slivers, scabs and weld spatter shall be removed. All rough edges shall be ground smooth and all contaminants (i.e., dirt or water-soluble salts) shall be removed by washing and rinsing with clean water.

2.6.5 Oil, grease or other foreign material shall be solvent cleaned in accordance with SSPC-SP 1 *Solvent Cleaning*.

2.6.6 Applicators shall verify that the surfaces are not contaminated with detrimental levels of non-visible soluble salts. Chloride levels shall be less than or equal to 20 mg/m^2 (conversions to ppm shall follow the instructions in the salt test kit manual). Salt testing shall be done prior to blast cleaning as per the frequencies listed in Table 2-3 of this Specification. Chlorides shall be removed using distilled water and repeat salt testing. This shall be continued until chlorides are within acceptable levels.

2.6.7 The ambient conditions, surface temperature, dew point and relative humidity shall be monitored and recorded at the beginning of each shift and every four (4) hours thereafter. If ambient conditions change, additional measurements shall be taken.

2.6.8 During abrasive blast cleaning and until priming, the surface shall be dry and the surface temperature shall be at least 3C° (5F°) above the dew point temperature.

2.6.9 The pipe surface temperature shall be measured using a surface contact thermometer. The temperature shall be maintained within the Manufacturer's recommended range.

2.6.10 One of the following Company-approved abrasives shall be used:

- Green Diamond
- Black Beauty
- Black Magic
- Starblast XL
- Black Shot II
- Black Lightning

A Company-approved equivalent may be used in lieu of the abrasives listed above. Contact the Responsible Engineer for approval of alternative equivalent abrasives. The use of reclaimed/recycled blast cleaning abrasives is not permitted except where metallic grit is employed in automatic centrifugal cleaning machines, or where blasting enclosures have been approved by the Company. Copper-bearing abrasives and steel shot shall not be used.

2.6.11 The abrasive blast media shall be dry and shall contain no contaminants injurious to the performance of the paint.

2.6.12 If Company approved abrasives are used, soluble salt or oil contamination testing on the abrasive is not required provided the abrasives are packaged and stored in accordance with the Manufacturer's recommendations. If the Company Coating Inspector suspects the abrasive being used is contaminated or is not listed in the approved abrasive list, testing of the abrasive is required.

2.6.13 If an alternative equivalent abrasive is used, soluble salt or oil contamination testing shall be conducted daily. Bulk orders of abrasive shall be tested once per load to confirm that each shipment of abrasive does not contain soluble salts or oil contamination.

2.6.14 Chloride testing shall be conducted as follows:

1. A sample of at least 100 mL (3.38 fl. oz.) of abrasive is mixed with an equal volume of distilled water in a clean transparent container.
2. The mixture is agitated for at least thirty (30) seconds. The abrasive is then allowed to settle to the bottom of the container.
3. The chloride content during testing shall not exceed 3 ppm (3 mg/L) and no oil shall be present when visually examined after remaining in the distilled water for 30 minutes.

2.6.15 The compressed air supply used for blast cleaning or conventional spraying shall be free of water and oil. Separators and filters shall be used on the compressed air supply to ensure that contaminants such as oil and water do not contaminate the steel surface. A blotter test shall be performed in accordance with ASTM D4285 *Standard Test Method for Indicating Oil or Water in Compressed Air* at the start of every working day to verify the cleanliness of the compressed air. Daily blotter tests shall be verified by the Company Coating Inspector for acceptability.

2.6.16 Any abrasive blasting unit or compressed air used for conventional spraying that fails testing shall be re-tested. If the second test fails, the unit shall be taken out of service until it is repaired and can pass the blotter test.

2.6.17 Steel surfaces intended for non-coastal environments shall be abrasive blasted to the cleanliness specified in APPENDIX A of this Specification.

2.6.18 Steel surfaces intended for coastal environments shall be abrasive blasted to the minimum cleanliness specified in SSPC-SP 10/NACE No. 2 *Near-White Blast Cleaning*.

2.6.19 The anchor profile shall be measured and recorded using replica tape and a spring micrometer in accordance with NACE SP0287 *Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape*. The frequency and number of readings shall be per section 2.10 and Table 2-4 of this Specification.

2.6.20 The anchor profile depth of blast-cleaned steel shall be in accordance with the TDS. If no anchor profile recommendations are provided by the TDS, request them in writing from the Manufacturer.

2.6.21 Areas that develop flash rust due to exposure to rain, moisture or humidity shall be given a sweep blast to return them to their original abrasive blast cleaned condition.

2.6.22 The abrasive cleaned surface shall be coated immediately. A sweep blast shall be carried out when an abrasive blasted surface is left overnight.

2.6.23 In shop applications that are climate controlled, abrasive cleaned surfaces may be left overnight prior to coating provided that the Company Coating Inspector reviews the cleaned steel surface to ensure that the required surface cleanliness has been maintained.

2.6.24 Power tool cleaning may be used as an alternative to abrasive blast cleaning for touch-up paint repairs and in certain field applications where abrasive blasting is not permitted due to hazards to the surrounding equipment or personnel. Written approval must be requested from the Company Coating Inspector in areas where abrasive blast cleaning is not permitted. Personnel completing the power tool clean shall demonstrate knowledge of proper use of the equipment to the Company Coating Inspector for acceptance. Power tool cleaning shall be to the SSPC-SP 15 *Commercial Grade Power Tool Cleaning* standard with a minimum anchor profile of 1.5 mils.

Note:

For any surface preparation tools, Operators shall provide proof of training or demonstrate knowledge of proper use of the tool to the Company Coating Inspector for acceptance. The MONTI Bristle Blaster is the preferred method of preparing bare areas. The surface shall be cleaned in accordance with SSPC-SP 15 if the MONTI tool is used.

2.6.25 Residual abrasive blast products shall be removed from the entire abrasive blasted surface using a dry and clean bristle brush, a vacuum or clean and dry compressed air.

2.6.26 Surface preparation may be subject to inspection by the Company Coating Inspector, at his or her discretion, before the paint is applied. The Company Coating Inspector shall be provided with reasonable advance notification of the expected time that the blasted surface will be ready for inspection.

2.6.27 Crevices, holes or other surfaces that cannot be accessed properly for painting shall be filled with a suitable caulking material. If the caulking material is applied prior to painting, the Manufacturer shall confirm in writing that the caulking material is compatible with the painting material.

2.7 Application—Paint Application

2.7.1 The Manufacturer’s application recommendations with respect to mixing, thinning, temperatures and curing shall be followed. In the event of a conflict between the Manufacturer’s recommendations and this Specification, the more stringent requirement shall govern.

2.7.2 The paint shall be spray applied in accordance with the paint Manufacturer’s instructions. The spray equipment shall be as recommended by the Manufacturer for each specific paint system.

2.7.3 Paints may be brush applied if spray equipment is not available and if the paint Manufacturer’s TDS allows paints to be applied in this manner. Brush applications should be limited to two (2) linear meters (6.5 ft.) in length. Brush application is acceptable if the scope of the project is strictly onsite girth welds. Brush application may also be used for repairs and touch ups. An Applicator using the brush method does not need to be pre-qualified by the Company, but should demonstrate the following to the Company Coating Inspector:

- They can brush apply the chosen paint system to the required dry film thickness (DFT).
- The applied paint system is aesthetically pleasing.

If longer sections are required to be brush applied, the Company Coating Inspector shall be consulted for review prior to acceptance.

2.7.4 For projects conducting all fabrication and painting on site, the Project may decide that areas of the pipe in contact with pipe supports require coating as per *TES-CO-EPU-GL Field-Applied External Liquid Coating Systems for Steel Pipes Specification*

(CAN-US-MEX) (EDMS No. 3671710). When required by a project, the Applicator shall apply liquid coating to a DFT of 1,020 µm to 1,780 µm (40 mils to 70 mils) around the circumference of the pipe in accordance with *TES-CO-EPU-GL*. The liquid coating shall extend a minimum of 150 mm (6 in.) beyond where the pipe support comes into contact with the piping. Once the liquid coating is cured, the surface shall be roughened by brush blasting, and a UV-resistant topcoat shall be applied as per this Specification. Contact the Responsible Engineer if further clarification is required.

2.7.5 A cutback of 10.2 cm (4 in.) shall be left adjacent to any area to be welded after painting.

2.7.6 The following areas shall be stripe painted, as they are challenging to paint and to ensure paint coverage and thickness requirements are met:

- boltholes
- bolts
- sharp edges
- flanges
- rough welds
- other areas with significant geometry

2.7.7 If an item to be painted has already been coated with an external liquid coating or a fusion bond epoxy (FBE) coating, the existing coating shall be roughened to remove gloss and an anchor profile shall be provided, followed by a topcoat. The topcoat shall be applied in accordance with this Specification. When transitioning from above ground to below ground, refer to of APPENDIX C.

2.7.8 Paint materials containing zinc must be sprayed from continuously agitated pots. The topcoat must be applied in a mist coat before applying a full coat to avoid blistering and craters. Consult the Manufacturer's TDS for information on overcoating inorganic zinc.

2.7.9 If the pot life of the paint material is exceeded, the material shall be discarded, the equipment shall be cleaned and new material shall be prepared.

2.7.10 Inorganic zinc primers shall pass the ASTM D4752 MEK test for cure before being topcoated. With permission from the Company Coating Inspector, a coin rub test may be performed instead.

2.7.11 The Applicator shall test the wet film thickness (WFT) of each coat (except the ethyl silicate zinc primer, as the zinc may provide a false reading) during application with a WFT gauge.

2.7.12 The DFT for each coat shall be measured and recorded for its specified range using a calibrated magnetic thickness gauge in accordance with SSPC-PA 2 *Procedure for Determining Conformance to Dry Coatings Thickness*.

2.7.13 The thickness gauge shall be calibrated once per shift or every 10 hrs (whichever comes first) to a National Institute of Standards and Technology (NIST) *Certified Coating Thickness Standard*, or gauge Manufacturer supplied shims.

2.7.14 The minimum DFT for the primer, intermediate coat and topcoat shall be in accordance with Appendix Table A-1 and Appendix Table B-1. Multiple coats may be required to achieve the minimum DFT for each layer. Refer to the applicable Manufacturer’s painting procedure for the minimum and maximum DFT per coat.

2.7.15 Some primers listed within this Specification, specifically inorganic zincs, are film thickness sensitive, and cracking may occur if applied too thick. These primers shall be applied in accordance with the thicknesses specified in the applicable TDS. Inorganic zincs (paint code P7) can be found in Appendix Table A-2.

2.7.16 The cured paint shall be visually inspected for film defects. The following defects are not acceptable and require repair at the Applicator’s expense:

- runs
- sags
- embedded debris
- voids
- overspray
- mud cracking
- inadequate cure
- lack of adhesion

2.7.17 Tees shall not be painted until after they have been hydrotested to avoid damage to the paint system. In the event that tees are painted prior to the hydrotest, inspect the crotch areas of the tees to ensure no damage has occurred to the applied paint system after the hydrotest. If damage to the paint system occurs, repairs shall be conducted in accordance with this Specification.

2.7.18 Above ground flanges on the Columbia Pipeline Group (CPG) system shall be filled and wrapped as per the application procedure in APPENDIX D.

2.8 Application—Repairs

2.8.1 Before applying the next coat, the underlying paints shall be examined for damaged and/or contaminated areas. The following repairs shall be performed where required:

- For repairs up to 2 mm (1/16 in.) in diameter, roughen the surface of the parent coating to remove gloss around the holiday to a distance of at least 25 mm (1 in.). Use 80 grit to 120 grit sandpaper or light sweep blasting.
- For repair areas less than or equal to 25 cm^2 (4 in.^{2}), blast clean the affected areas to the applicable standard or hand or power tool clean in accordance with SSPC-SP 15 *Commercial Grade Power Tool Cleaning*.

- For repair areas exceeding 25 cm^2 (4 $in.^2$), abrasive blast clean in accordance with section 2.6 of this Specification.
- Feather out the edges.
- Solvent clean dirt, loose deposits, oil and grease in accordance with SSPC-SP 1 *Solvent Cleaning* using solvents that will not have a deleterious effect on the primer.
- Remove salts with clean water by brush or power washing.
- After surface preparation, apply primer to areas requiring touch-up and allow to cure prior to application of the next coat.
- Ensure abraded and repaired areas overlap the underlying coating by a minimum of 25 mm (1 in.).

2.8.2 Limit brush and roller application of inorganic zinc primers to small repair areas unless the paint Manufacturer's TDS states brush and roller applications are an acceptable method of application.

2.9 Inspection and Testing—General

2.9.1 The Applicator's Inspector shall be on site during the surface preparation and painting application.

2.9.2 The Applicator shall be responsible for the quality of all of their operations, which shall be controlled and maintained by periodic inspection and testing.

2.9.3 The Applicator shall provide all calibrated test instruments' calibration records to the Company Coating Inspector for verification. All test instruments shall be calibrated on a yearly basis.

2.9.4 All quality control (QC) measurements and inspections shall be done by the Applicator and recorded. Applicators may use the Company form *TEF-CO-PAINT-GL Coating Inspection Form for: Above Ground Painting (CAN-US-MEX)* (EDMS No. 5880500).The records for items in Table 2-3 shall be available for review by the Company at all times and the Applicator shall submit originals to the Company at the end of the Project.

Table 2-3: QC Testing

Test Type	Test Reference	Frequency
Environmental conditions and steel surface temperature	Sections 2.6.7, and 2.6.8	Start of shift and every 4 hours thereafter (minimum)
Visual inspection of steel surfaces for contaminates	Section 2.6.4	All items to be coated
Abrasive contamination testing (as applicable)	Contact the Responsible Engineer, section 2.6.14	Sections 2.6.12 and 2.6.13

Test Type	Test Reference	Frequency
Abrasive blast air blotter test	ASTM D4285, sections 2.6.15 and 2.6.16	Beginning of each shift (sections 2.6.15 and 2.6.16)
Visual exam of cleaned steel surfaces	SSPC-VIS 1, SSPC-SP 10, sections 2.6.5	All items cleaned
Salt contamination of the steel surface	SSPC Technology Guide 15, section 2.6.6	Test for soluble salt once per shift (maximum of 10 hours between tests). If a truckload of items requires testing, test twice per truckload. For integrity activities, frequency shall be a minimum of once per site.
Abrasive blast profile measurements	NACE SP0287, section 2.6.19	Sections 2.10.1, 2.10.2 and Table 2-4
Monitor steel pre-heat (if required)	As required by Manufacturer datasheets	Every item to be coated
ASTM D4752 MEK test	Section 2.7.10	Every item coated with inorganic zinc primer
DFT	SSPC-PA 2, sections 2.7.12 and 2.7.14	Section 2.7.13
Visual inspection of application	Section 2.7.16	Every item coated
Holiday detection	NACE SP0188, section 2.11.1	Painted items under thermal or acoustical insulation (section 2.11.1)

2.9.5 Additional sampling shall be performed where a test fails to conform to the specified requirements to ascertain the extent of the non-conforming paint. At the Company's discretion, all affected paint determined to have failed the testing may be rejected. Rejected items shall be stripped and repainted at the expense of the Applicator.

2.10 Inspection and Testing—Anchor Profile Measurement Frequency

2.10.1 Surface profile measurements shall be conducted in accordance with Table 2-4. The minimum number of readings listed within the table shall be conducted.

2.10.2 If a trailer load or large shipment of piping, fittings, valves, pipe supports or multiple pre-fabricated assemblies are to be abrasively cleaned for painting, the frequency of profile measurements listed may be changed to four (4) measurements per hour of abrasive blasting at the discretion of the Company Coating Inspector. Blast profile reading measurements shall be taken at different locations on the items abrasively cleaned. If this process occurs, it shall be documented on the Company approved QC form.

Table 2-4: Profile Measurement Recordings

Object	Size	Minimum Number of Spot Readings
Pipe	Every 20 linear meters (65 ft.)	4 randomly spaced along and around the pipe
Fittings	Each, less than 20 linear meters (65 ft.)	4 randomly spaced along and around the fitting
Pipe sections	Each, less than 20 linear meters (65 ft.)	4 randomly spaced along and around the pipe section
Girth welds and tie-in welds	1 set of 3 readings per 25 joints	3 per joint in different quadrants of the girth weld or tie-in weld
Valves	Each	3 along and around the valve for ≥ 406 mm (16 in.) 2 along and around the valve for < 406 mm (16 in.)
Pre-fabricated valve assemblies (all sizes)	Each assembly	6 randomly spaced along and around the assembly for ≥ 406 mm (16 in.) 4 randomly spaced along and around the assembly for < 406 mm (16 in.)
Large repair areas	Surfaces of repair areas exceeding 25 cm^2 (4 $in.^2$)	1 reading every 2nd repair area
Other items not listed	N/A	4 readings per hour of blasting

2.11 Inspection and Testing—Holiday Detection

2.11.1 Paint systems intended for service under thermal or acoustical insulation, inside or outside a building, shall be confirmed to be free of holidays by inspection with a low-voltage wet sponge holiday tester in accordance with NACE SP0188 *Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates*.

2.12 Handling and Storage

2.12.1 Painted items shall be handled, transported and stored in a manner that avoids damage to the paint system or items. Any damage to the items or the paint shall be repaired in accordance with the applicable standards and this Specification.

3 VARIANCES

Any deviation shall follow the Company Management of Change (MOC) Variance Procedure (EDMS No. 7728702). External vendors shall contact the Company Responsible Engineer or another authorized Company representative for variance approval.

4 ROLES AND RESPONSIBILITIES

Table 4-1 lists the roles and responsibilities required for the use of this Specification.

Table 4-1: Roles and Responsibilities

Role	Responsibilities
Applicator	The Applicator is responsible for ensuring that the proper method is used to apply the appropriate paint materials to the appropriate surface area.
Company Coating Inspector	The Company Coating Inspector is responsible for ensuring that the Applicator uses the proper method to apply the paint materials to the appropriate surface area, and that the results meet the standards set forth by the Company in this Specification.
Responsible Engineer	The Responsible Engineer is accountable for ensuring that the plan set forth by the Applicator meets the standards set forth by the Company, and that resolution to any questions that arise from the use of this Specification meet the standards set forth by the Company.
Manufacturer	The Manufacturer is responsible for ensuring that the product produced for application is produced in accordance with the documentation that it provides to the Applicator.

5 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are listed in Table 5-1, Table 5-2 and Table 5-3. Use the latest document revision, unless otherwise approved by TransCanada.

Table 5-1: Regulatory References

Organization/Document No.	Title
For this Specification, there are no specific regulatory references.	

Table 5-2: External Industry References

Organization/Document No.	Title
American Society for Testing and Materials (ASTM)	ASTM D4285 Standard Test Method for Indicating Oil or Water in Compressed Air
	ASTM D4752 Standard Practice for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub
International Organization for Standardization (ISO)	ISO 9001 Quality Management Systems – Requirements
	ISO 12944 Paints and varnishes – Corrosion protection of steel structures by protective paint systems
National Association of Corrosion	NACE SP0188 Discontinuity (Holiday) Testing of New Protective Coatings

Organization/Document No.	Title
Engineers (NACE) International	on Conductive Substrates
	NACE SP0287 Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape
The Society for Protective Coatings (SSPC)	SSPC-PA 2 Procedure for Determining Conformance to Dry Coatings Thickness
	SSPC-SP 1 Solvent Cleaning
	SSPC-SP 2 Hand Tool Cleaning
	SSPC-SP 6/NACE No. 3 Commercial Blast Cleaning
	SSPC-SP 10/NACE No. 2 Near-White Blast Cleaning
	SSPC-SP 15 Commercial Grade Power Tool Cleaning
	SSPC Technology Guide 15 Field Methods for Extraction and Analysis of Soluble Salts on Steel and Other Nonporous Substrates
	SSPC-VIS 1 Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning, 2002 Revision

Table 5-3: Internal References

Document No.	Title
EDMS No. 5880500	*TEF-CO-PAINT-GL Coating Inspection Form for: Above Ground Painting (CAN-US-MEX)*
EDMS No. 3671710	*TES-CO-EPU-GL Field-Applied External Liquid Coating Systems for Steel Pipes Specification (CAN-US-MEX)*

6 DOCUMENTATION AND RECORDKEEPING

All Project documentation is held in the Project file and stored in accordance with the Company's guidelines.

All technical document submittal requirements are provided in the Vendor Technical Document Requirements List (VDRL) included with the proposal request or purchase order.

7 DOCUMENT HISTORY

Rev.		
10	**Description**	**Effective Date**
	This document is the new version of TES-COAT-PAINT-GL, updated in accordance with the CPG Integration.	2017-Aug-01
	Rationale Statement	**Responsible Engineer**
	This document was developed / revised in order to address the following requirements: • CPG Integration	Aissa Van Der Veen, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to integrate the TransCanada and CPG documents.	Aissa Van Der Veen, P. Eng.
Rev.		
09	**Description**	**Effective Date**
	This document is the new version of TES-COAT-PAINT-GL, updated in accordance with the documentation Streamlining initiative.	2016-Nov-01
	Rationale Statement	**Responsible Engineer**
	This document was developed / revised in order to address the following requirements: • Streamlining of content to reflect the updated document collection of the coatings group	Aissa Van Der Veen, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Coatings group and to make it more easily accessible to those who use it.	Aissa Van Der Veen, P. Eng.

8 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
Update to format and content	As a part of the Streamlining and Simplification process, this document has been reformatted and updated to reflect the TransCanada template.

9 APPROVALS

APPROVALS		
Originator: Aissa Van Der Veen, P. Eng. Welding and Materials Engineering	Signature	July 12, 2017 Date
Reviewer: Niteesha Falcon, P. Eng. Welding and Materials Engineering	Niteesha Falcon Signature	July 15, 2017 Date
Reviewer: Connor McManus, P. Eng. Gas Projects Engineering	FOR Signature Connor McManus	JULY 14, 2017 Date
Reviewer: Daniel Herpin, Manager Corrosion Services	Signature	July 13, 2017 Date
Responsible Engineer: Aissa Van Der Veen, P. Eng. Welding and Materials Engineering	Signature July 15, 2017 Date	PROFESSIONAL ENGINEER ALBERTA AISSA VAN DER VEEN APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, P. Eng., Manager Welding and Materials Engineering	Signature	July 15, 2017 Date

APPENDIX A APPROVED PAINTS FOR ISO 12944 CLASSIFICATION C1, C2 AND C3

This Appendix lists approved paints for ISO 12944 Classification C1 & C2 (heated building/neutral atmosphere, rural areas and low pollution) and C3 (urban and industrial atmospheres, moderate sulphur dioxide levels and production areas with high humidity). This procedure applies to both shop and field work under a full range of operating conditions. These systems are not suitable for coastal environments (ISO 12944 C4).

The following tables list the approved paint Manufacturers and the generic product description. There are nine (9) paint Manufacturers listed, which are displayed in no specific order.

A-1 PAINT SYSTEMS

The list of paintable items present within the following tables is not exhaustive. If an item that requires painting is not listed in the tables, Projects are requested to review where the item is to be installed (inside or outside) and what items are attached to it (upstream or downstream). If the upstream or downstream items are listed and the item to be painted is in the same atmospheric classification and does not generate or induce heat into the system, the paint system of the listed items may be used. Refer to Appendix Table A-2 and Appendix Table A-3 for primer and topcoat product information.

Appendix Table A-1: Paint Systems

Paint System**	Items to be Painted	Surface Prep	Primer		Topcoat		Total DFT target range for these environments	Comments
			Paint Code	Minimum DFT	Paint Code	Minimum DFT		
Paint Systems for Items Within Buildings (Indoor Atmospheric Service, C1 & C2 Environments)								
PS-I-2	Steel Floor Grating & Plates, Steel Stairs, Ladders & Walkways	SP-6	P1	6 mils	-	-	6 mils minimum	• Items may be galvanized as per the Industry Standard (2 mils minimum). • Painting is required if specified in the Project description.

Paint System**	Items to be Painted	Surface Prep	Primer		Topcoat		Total DFT target range for these environments	Comments
			Paint Code	Minimum DFT	Paint Code	Minimum DFT		
Paint Systems for Items Outside Buildings (Outdoor or Wet Atmospheric Service, C3 Environments)*								
PS-O-1	Pipe and Cable Supports	SP-6	P8	8 mils	-	-	8 mils minimum	• If piping and cable supports are aluminum or pre-finished, no painting is required. • For small maintenance and touch ups, surface preparation to SP-15 is acceptable in place of SP-6. • This does not include structural steel such as I-beams and above ground piles. These items may be galvanized as per the Industry Standard (2 mils minimum).
		SP-6	P1	6 mils	F2	2 mils		
		SP-6	P1	6 mils	F10	2 mils		
PS-O-2	Steel Ladders, Stairs and Treads, Grating, Walkways, Handrails, Checker plates	SP-6	P1	6 mils	F2	2 mils	8 mils minimum	• For checker plates located outside of buildings. • Items may be galvanized as per the Industry Standard (2 mils minimum).
		SP-6	P1	6 mils	F10	2 mils		
PS-O-5	Steel Water Tank Exterior	SP-6	P1	6 mils	F2	2 mils	8 mils minimum	• For small maintenance and touch ups, surface preparation to SP-15 is acceptable in place of SP-6.
		SP-6	P1	6 mils	F10	2 mils		
		SP-10	P8	8 mils	-	-		

Paint System**	Items to be Painted	Surface Prep	Primer		Topcoat		Total DFT target range for these environments	Comments
			Paint Code	Minimum DFT	Paint Code	Minimum DFT		
Paint Systems for Equipment Within Buildings (Dry Indoor Atmospheric Service, C1 & C2 Environments)								
PS-I-5	General Equipment (except compressor), and High Pressure Pipe: Natural Gas, Air, Oil or Water (including composite repair sleeves)	SP-6	P1	6 mils	-	-	6 mils minimum	
PS-I-7	High Pressure Pipe in trench (not buried): Natural Gas, Air, Oil or Water (including composite repair sleeves)	SP-10	P4	4 mils	P1	4 mils	6 mils minimum	• Organic Zinc Rich Primer (P7) is allowed as a substitute to P4 if cool dry ambient conditions will retard curing of the inorganic zinc primer. It is also allowed for painting repairs.
		SP-6	P1	4 mils	F10	2 mils		
PS-I-8	Insulated Pipe (Natural Gas, Air, Oil or Water) (thermal or acoustic insulation)	SP-6	P6	6 mils	-	-	6 mils minimum	• Topcoat paint shall be confirmed to be free of holidays inside and outside of buildings.
PS-I-9	Turbine (Exhaust) Expansion Joint (Exhaust) Muffler – Max temp 399°C (750°F)	SP-10	P4	4 mils	F7 (b)	1.5 mils	6 mils minimum	
PS-I-10	Turbine (Exhaust) Expansion Joint (Exhaust) Muffler – Max temp 538°C (1000°F)	SP-10	P9	4 mils	F7 (a)	1.5 mils	6 mils minimum	

Paint System**	Items to be Painted	Surface Prep	Primer		Topcoat		Total DFT target range for these environments	Comments
			Paint Code	Minimum DFT	Paint Code	Minimum DFT		
Paint Systems for Equipment Outside Buildings (Outdoor or Wet Atmospheric Service, C3 Environments)								
PS-O-6	Air Intake Filter ,Fin/Fan Cooler, Blow off cleaner (Air Unit and Auxiliary Engine), Post (Instrument) Scrubber (Air),Pipe (Air, Water, Oil), Surge Bottle	SP-6	P8	8 mils	-	-	8 mils minimum	
		SP-6	P1	6 mils	F2	2 mils		
		SP-6	P1	6 mils	F10	2 mils		
PS-O-7	Turbine (Exhaust) Expansion Joint (Exhaust) Muffler – Max temp 399°C (750°F)	SP-10	P4	6 mils	F7 (b)	1.5 mils	8 mils minimum	• Organic Zinc Rich Primer (P7) is allowed as a substitute to P4 if cool dry ambient conditions will retard curing of the inorganic zinc primer. It is also allowed for painting repairs.
PS-O-8	Turbine (Exhaust) Expansion Joint (Exhaust) Muffler – Max temp 538°C (1000°F)	SP-10	P9	6 mils	F7 (a)	1.5 mils	8 mils minimum	
PS-O-9	Piping system and Separators (Natural Gas and Crude Oil) (Including composite repair sleeves), Heat Exchangers	SP-10	P4	5 mils	F9	3 mils	8 mils minimum	• Organic Zinc Rich Primer (P7) is allowed as a substitute to P4 if cool dry ambient conditions will retard curing of the inorganic zinc primer. It is also allowed for painting repairs.
		SP-6	P1	6 mils	F10	2 mils		
PS-O-10	Insulated Pipe and other insulated surfaces (thermal or acoustic insulation)	SP-10	P6	5 mils	P6	5 mils	8 mils minimum	• Topcoat paint shall be confirmed to be free of holidays inside and outside of buildings.

Notes:

* Painting is not required on the underside of meter station skids or compressor station skids and other areas of the skid that are not readily visible.

** The "O" in the paint system code refers to items outside a building and the "I" in the paint system code refers to items inside a building.

A-2 PRIMERS AND TOPCOATS

The entire paint system must be selected from a single Manufacturer.

Appendix Table A-2: Primer Product Name by Manufacturer

Paint Code	Paint Type	Manufacturer								
		Amercoat/PPG	Carboline	Cloverdale	Devoe	Hempel	Highland International	International	Sherwin Williams	Tnemec
P1	Surface Tolerant Epoxy	Amercoat 370	Carboguard 890(1) or Carbomastic 615 HS	ClovaMastic HB Low Temp Cure Epoxy 83110 Series	Bar Rust 236	Hempadur Fast Dry 17410	-	Interseal 670HS(2)	Macropoxy 646(3)	Epoxoline Series 141
P2	Universal Primer	PPG Multi-prime 4360	Carbocoat 150UP	Rustex low VOC primer 71044	Devprime 1407	Uni-Primer 13140	-	Interprime 198/298 shop/field(4)	Kem Bond HS	ChemPrime H.S. Series 37H
P4	Inorganic Zinc Rich Primer	Dimetcote 9	Carbozinc 11	ClovaZinc 2	Cathacoat 304L	Galvosil 15680	-	Interzinc 22	Zinc Clad II Plus	Tneme-Zinc Series 90-E92
P6	Phenolic / Novalac Epoxy	Hi-Temp 900(5)	Thermaline 450/ 450EP	ClovaLine 83375	-	Hempadur 85671	47 Series Chem-Temp Epoxy	Intertherm 228HS or Interbond 2340 UPC(5)	Cor-Cote HT	Novocoat SC 2200(5)
P7	Organic Zinc Rich Primer	Amercoat 68 HS	Carbozinc 859	ClovaZinc 3	Cathacoat 313	Hempadur Avantguard 750	-	Interzinc 52	Zinc Clad III HS	Tneme-Zinc Series 90-97
P8	Epoxy Polysiloxane	PSX 700(6)	-	-	-	Hempaxane Classic 55000	-	-	Sherloxane 800	-
P9	Zinc Primer (for Silicone Topcoat)	Dimetcote 9 Series	Carbozinc 11	ClovaTherm 83220	Cathacoat 304L	Galvosil 156801	335 Series	Interzinc 22	Zinc Clad II Plus(7)	Tneme-Zinc Series 90-E92

Paint Code	Paint Type	Manufacturer								
		Amercoat/PPG	Carboline	Cloverdale	Devoe	Hempel	Highland International	International	Sherwin Williams	Tnemec

Notes:

(1): For applications above 10°C (50°F) use Carboguard 890, for applications down to 2°C (35°F) use Carboguard 890LT and for applications down to -7°C (20°F) use Carbomastic 615HS (tan only). It is acceptable for CPG facilities to substitute Rustbond Polymeric Amine epoxy primer for repairs only.

(2): Use Intergard 345 for shop work.

(3): Use Macropoxy 846 for cold weather application

(4): The 198 is shop applied. The 298 is VOC compliant field applied.

(5): These paint products can be used as a standalone paint system for uninsulated pipe. Follow the Manufacturer's recommendations for thickness requirements and surface preparation. Ensure desired project colour can be obtained from the Manufacturer. A topcoat may be applied to achieve the desired colour.

(6): Use PSX 700FD in Canada or if fast dry is required.

(7): Use Heat Flex Hi Temp 1200 for low humidity environments.

Appendix Table A-3: Topcoat Product Name by Manufacturer

Paint Code	Paint Type	Manufacturer								
		Amercoat/PPG	Carboline	Cloverdale	Devoe	Hempel	Highland International	International	Sherwin Williams	Tnemec
F1	Alkyd Enamel	HPC Industrial Alkyd 4308 H Series	Carbocoat 8215	Industrial Enamel	Devlac 1431, Devlac 1433	Hempalin Enamel 52140	-	Interlac 665/ 665FD	Industrial Enamel HS	Tneme-Gloss Series 2H
F2	Polysiloxane Topcoat	PSX One	Carboxane 2000	Polysiloxane HP	-	Hempaxane Light 55030	-	Interfine 878	Polysiloxane 1k	UVX Series 740
F3	Water Borne Epoxy or Epoxy Acrylic	Aquapon WB 98-1 Series	Sanitile 255 or 555	ClovaShield	Truglaze 4420	Hempadur Mastic 45880	-	-	Pro-Industrial WB Catalyzed Epoxy	HB Tneme-Tufcoat Series 113/114

Paint	Paint Type	Manufacturer									
F5	Water Borne Acrylic	Pitt-Tech Plus 90-1310	Carbocrylic 3359	Ecologic WB Speed Enamel	Devcryl 1449	-	-	-	DTM Acrylic	Enduratone Series 1029
F7 (a)	Silicone Aluminum	Hi Temp 1000[1] or Dimetcote 9	Thermaline 4700	ClovaTherm 83225	-	Silicone Aluminum 56913	815 Series	Intertherm 50	Heat Flex Hi-Temp 1000	-
F7 (b)	High Temp Inorganic	Hi Temp 1027	Thermaline 4000	HH Aluminum 83203	-	Versiline 56990	-	Interbond 1202UPC	Heat Flex Hi Temp 1200	-
F8	Abrasion Resistant Epoxy	MegaSeal HSPC/PPG MegaSeal SL	Sanitile 945SL	NSP 100/200	Devgrip 238	Hempadur Multi-Strength 35530	-	Interzone 954	Armorseal 650 SL/RC	Epoxoline Series 142
F9	Modified Polysiloxane	PSX 700[2]	Carboxane 2000	Polysiloxane HP	-	Hempaxane Light 55030	-	Interfine 979	Sheloxane 800	UVX Series 740
F10	Polyurethanes	Amercoat 450HS	Carbothane 134HG or HB, Carbothane 133HG or HB[3]	AmourShield	Devthane 389H or Devthane 379[4]	Hempathane HS 55610	-	Interthane 990V	Acrolon 218HS or Envirolastic 940PA	Endura-Shield Series 1095

Notes:

(1): Cure for 2 hrs at 149°C (300°F) before service, for other colors use Amercoat 873, no heat cure is required.

(2): Use PSX 700FD in Canada or if fast dry is required.

(3): For a satin gloss finish to aid in hiding weld seams and other types of defects, use Carbothane 133HB.

(4): Devthane 379 is for use in Canada and Devthane 379H is for use in the U.S.

APPENDIX B PAINT SYSTEMS FOR ISO 12944 CLASSIFICATION C4 (INDUSTRIAL AND COASTAL AREAS, CHEMICAL PROCESSING PLANTS)

B-1 PAINT SYSTEMS

This Appendix lists the approved paints for ISO 12944 Classification C4 (industrial and coastal areas with moderate salinity and chemical processing plants). Coastal environments include systems within 5 km (3 mi.) of salt or brackish water and areas exposed to brine or salt. Coating materials shall be selected and applied as systems in accordance with the intended service as required by Appendix Table B-1.

This Procedure applies to both shop and field work under a full range of operating conditions. The following tables list the approved paint Manufacturers and the generic product description.

Refer to Appendix Table B-2, Appendix Table B-3, Appendix Table B-4 and Appendix Table B-5 for primer, intermediate coat and topcoat information.

Appendix Table B-1: Paint Systems

Paint System	Items to be Painted	Maximum Service Temperature	Surface Prep	Primer(1)		Intermediate Coat		Topcoat		Total DFT target range for these environments	Comments
				Paint Code	Minimum DFT	Paint Code	Minimum DFT	Paint Code	Minimum DFT		
PS-C-1	Piping and structural steel	120ºC (248ºF)		PC1	3 mils	IC1	7 mils	FC1	3 mils	13 mils	
PS-C-2	Pipe and cable supports	120ºC (248ºF)		PC2	4 mils	-	-	FC2	7 mils	11 mils	
PS-C-4	Steel under insulation (thermal or acoustic)	260ºC (450ºF)		PC3	6 mils	-	-	FC3	7 mils	13 mils	• Coating shall be confirmed to be free of holidays with a wet sponge holiday tester. Phenolic/Novalac Epoxies typically are suitable for service temperatures up to 200°C to 260ºC (400°F to450ºF); refer to the Manufacturer's product datasheet for maximum service temperatures.

Notes:

(1): For maintenance situations, when the method of surface preparation is not abrasive blast cleaning (e.g., water blasting or power tool cleaning) the Surface Tolerant Primer should be used. Refer to Appendix Table B-3.

B-2 PRIMERS AND TOPCOATS

The entire paint system must be selected from a single Manufacturer.

Appendix Table B-2: Primer Product Names by Manufacturer

Paint Code	Paint Type	Manufacturer								
		Amercoat / PPG	Carboline	Cloverdale	Devoe	Hempel	Highland International	International	Sherwin Williams	Tnemec
PC1	Zinc	Amercoat 68HS	Carbozinc 859	ClovaZinc 3	Cathcoat 313	Hempadur Avantguard 750	-	Interzinc 52	ZincClad III HS	Tneme-zinc Series 90-97
PC2	Zinc	Amercoat 68HS	Carbozinc 859	ClovaZinc 3	-	Hempadur Avantguard 750	-	Interzinc 52	ZincClad III HS	Tneme-zinc series 90-97
PC3	-	Amercoat 90HS	Thermaline 450EP	ClovaMastic Micaceous HR Mastic	-	Hempadur 85671	47 Series Chem-Temp Epoxy	Intertherm 228HS or Interbond 2340 UPC	Cor-Cote HT	Epoxoline WB Series 1224

Appendix Table B-3: Alternative Primer

Paint Type	Manufacturer								
	Amercoat / PPG	Carboline	Cloverdale	Devoe	Hempel	Highland International	International	Sherwin Williams	Tnemec
Surface Tolerant Primer	Amercoat 370	Carbomastic 15(1)	ClovaMastic 83110 Series	-	Hempadur Mastic 45880	-	Interseal 670HS	Sea-Guard 6100	Epoxoline Series 141

Notes:

(1): For maintenance painting Carbomastic 615 may be used instead of Carbomastic 15 for cold or slightly damp surfaces.

Appendix Table B-4: Intermediate Coat Product Names by Manufacturer

Paint Code	Paint Type	Manufacturer								
		Amercoat / PPG	Carboline	Cloverdale	Devoe	Hempel	Highland International	International	Sherwin Williams	Tnemec
IC1	Epoxy	Amercoat 385	Carboguard 893	ClovaGuard	Bar Rust 236	Hempadur Fast Dry 17410	-	Interseal 670HS or Intergard 475HS	Macropoxy 646(1)	Hi-Build Epoxoline Series 66 HS(2)

Notes:

(1): For cold weather application use Macropoxy 846.

(2): For cold weather application use Hi-Build Epoxoline Series 161 HS Low Temperature

Appendix Table B-5: Topcoat Product Names by Manufacturer

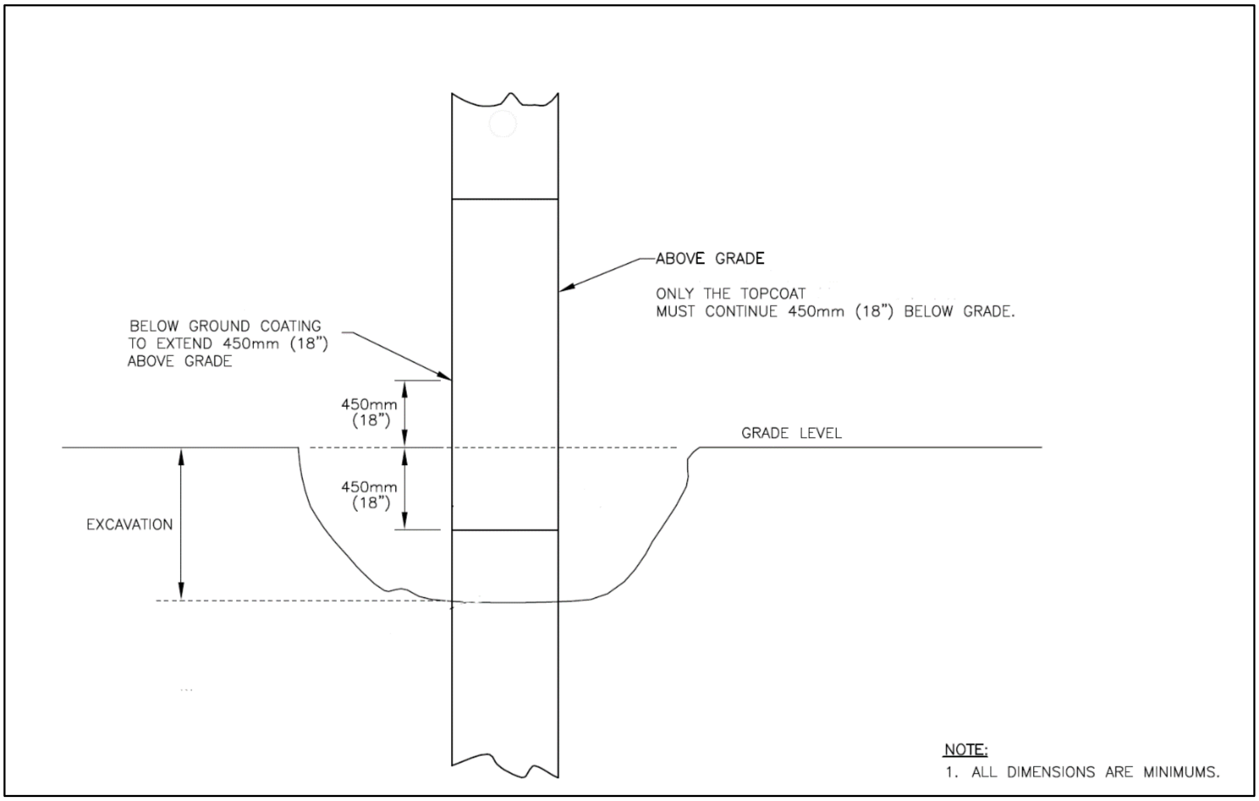
Paint Code	Paint Type	Manufacturer								
		Amercoat / PPG	Carboline	Cloverdale	Devoe	Hempel	Highland International	International	Sherwin Williams	Tnemec
FC1	Urethane	Amercoat 450HS	Carbothane 134HG	AmourShield	Devthane 379V	Hempathane HS 55610	-	Interthane 990 V	Acrolon 218 HS	Endura Shield II Series 1074
FC2	Polysiloxane	PSX 700	Carboxane 2000	Polysiloxane HP	-	Hempaxane Light 55030	-	Interfine 979 HS	Sherloxane 800	UVX Series 740
FC3	-	Amercoat 90HS	Thermaline 450EP	ClovaMastic Micaceous HR Mastic	-	Hempadur 85671	47 Series Chem-Temp Epoxy	Intertherm 228HS or Interbond 2340 UPC	Cor-Cote HT	Epoxoline WB Series 1224

APPENDIX C RISERS AND ABOVE GRADE TRANSITION AREAS

Risers and transition areas shall be coated with spray or brush grade liquid coating and shall be applied in accordance with *TES-CO-EPU-GL Field-Applied External Liquid Coating Systems for Steel Pipes Specification (CAN-US-MEX)* (EDMS No. 3671710). The below grade liquid coating shall continue above ground for a minimum of 45 cm (18 in.).

For areas with stable soils, the above ground topcoat paint must continue approximately 45 cm (18 in.) below ground. For areas with unstable soils, the above ground topcoat paint must continue for approximately one (1) meter (3 ft.) underground. The paint topcoat shall be applied in accordance with this Specification.

For existing FBE or liquid coating systems, only the topcoat of the above ground paint system must continue, approximately 45 cm (18 in.) below grade, and be applied in accordance with this Specification. For more details, refer to Appendix Figure C-1.



Appendix Figure C-1: Riser Coating Detail with Transition to FBE or Liquid Coating Systems

APPENDIX D ABOVE GROUND FILLING AND OVER WRAPPING FLANGES PROCEDURE (CPG ONLY)

D-1 SCOPE

This Procedure provides guidance for the application of filling and over-wrapping flange assemblies for above ground applications.

D-2 APPROVED MATERIALS

Trenton #2 Wax Tape above ground (maximum temperature 60°C (140° F)).

D-3 PREREQUISITES

The following items *must* be completed or reviewed before beginning this Procedure.

- Consideration needs to be given for the operating temperature of the flange assembly.

D-4 PROCEDURE

Filling Procedure – Above Ground

1. Assess the condition of the entire flange assembly (i.e., bolts, nuts, gaskets and pipe) for corrosion on existing facilities.
2. Prior to filling, the flange should be cleaned, at a minimum, per SSPC-SP 1 *Solvent Cleaning* to remove any grease, oil, chemical contaminant, etc. If necessary, utilize SSPC-SP 2 *Hand Tool Cleaning* to remove any loose debris, rust, flaking paint, etc. The area between the flanges can be blown out with compressed air to remove any loose deposits.
3. Lightly coat the gasket/flange area with wax tape primer. Insert the profiling mastic into the flange, working the product around the flange bolts and into the flange crevice. Remove the excess profiling mastic from the flange circumference. Install Trenton #2 Wax Tape around the flange. A fiberglass outer wrap and/or paint can also be applied where needed.

TES-CO-FBE-GL External Fusion Bond Epoxy for Steel Pipe Specification (CAN-US-MEX)		TransCanada In business to deliver

PURPOSE

This Specification outlines the requirements for the qualification, application, inspection, repair and testing of plant-applied fusion bond epoxy (FBE) coatings intended for gas and liquid pipeline systems.

SCOPE/APPLICABILITY

This Specification shall comply with the requirements of the latest edition of Canadian Standards Association (CSA) Z662 *Oil and Gas Pipeline Systems* and CSA Z245.20-14 *Plant-applied external fusion bond epoxy coating for steel pipe* and any amendment, supplement or errata issued by CSA.

This Specification shall be used in conjunction with CSA Z245.20-14 and covers the requirements that are in addition to the CSA Z245.20-14 requirements.

The numbering of clauses in this Specification corresponds to the numbering of clauses in CSA Z245.20-14 where the subject is covered, with any additional clauses numbered sequentially.

A pre-qualification of each application facility is required prior to the application of any approved FBE powders. The pre-qualification tests to be undertaken are provided in Table 12-1 (System 1A) and Table 12-2 (System 2B and 2C) of this Specification.

The coating Applicator facilities shall be Company approved Applicators.

This Specification applies to all divisions of the Company and its wholly-owned subsidiaries, and all operated entities/facilities in Canada, the United States (U.S.) and Mexico.

Within this Specification, TransCanada is referred to as the Company.

Wherein governmental or regulatory requirements conflict with this Specification, the more stringent requirement shall govern.

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1 SCOPE

This Specification outlines the technical requirements for the qualification, application, inspection, testing, handling and storage of materials required for plant-applied fusion bond epoxy (FBE) corrosion coating and abrasion resistant FBE coating applied externally to bare steel pipe for gas and liquid pipeline systems. FBE is suitable for piping sizes NPS 4 and larger. Depending on the application facility, there may be some wall thickness, length and weight restrictions. Due to heating requirements, this Specification (as written) may not be suitable for a strain based pipe design.

This Specification applies to the Company and to all coating Applicators of FBE coating and abrasion resistant FBE coating for newly constructed gas and liquid pipeline systems and pipe replacement programs.

The coating Applicator shall be referred to as the Contractor and the Company's authorized representatives shall be referred to as the Inspectors.

If the Contractor is familiar with the work to be performed pursuant to this Specification, the Contractor shall represent, and has the responsibility of compliance with, all of the applicable regulations, codes, standards and specifications (including those related to occupational safety and environmental protection).

The FBE coating in this Specification is suitable for operating temperatures up to 65°C (150°F) and ambient installation temperatures of -30°C (-20°F) and higher.

The conversion of units from metric to imperial and vice versa shall be to the nearest approximate values of zero or five.

The FBE powders, application process and coating system shall meet the requirements of CSA Z245.20-14 and this Specification.

1.2 This Specification covers the following coating systems:

- System 1A (FBE corrosion coating or single layer)
- System 2B (FBE corrosion coating and FBE resistant overlay or ARO or dual layer)
- System 2C (FBE corrosion coating and an anti-slip overcoat)

2 REFERENCE PUBLICATIONS

All documentation required by CSA Z245.20-14 and this Specification shall be available at the coating Applicator's facilities.

In addition, the latest versions of the following should be available and complied with:

- DOT 49 CFR 192 *Transportation of Natural and Other Gas by Pipeline*
- DOT 49 CFR 195 *Transportation of Hazardous Liquids by Pipeline*
- NACE SP 0394 *Application, Performance, and Quality Control of Plant-Applied Single Layer Fusion-Bonded Epoxy External Pipe Coating*

3 DEFINITIONS

The following definitions shall be added to those referenced by CSA Z245.20-14:

Crack

A visually determined tear in the coating that extends through to the pipe surface.

Pimple

Gas pockets within the coating that are open to the pipe surface but may not be open to the atmosphere. Pimples appear as small protrusions on the coating surface.

Purchase order

The purchasing document used to purchase coated pipe.

Stress or stretch marks

A tear in the coating that results from flexibility testing that does not extend through to the steel surface. These marks are detected by unaided visual examination but may be verified with the use of up to 40 times magnification. Stress or stretch marks are not to be confused with white marks (which are not open to the atmosphere or steel surface).

Weld gassing

Numerous defects in the coating that are predominately located on submerged-arc welds due to the escape of trapped gasses. Such defects are usually detected with electrical inspection in the coating application plant.

4 GENERAL REQUIREMENTS

4.1.1 Standard Requirements

The following clauses are in the Company purchase order:

(b) pipe quantity, outside diameter, wall thickness, and nominal length;

(c) coating system (1A, 1B, 2A, 2B, 2C, or 3);

(d) bare pipe standard or specification designation; and

(f) cutback length and tolerance for both ends of pipe.

The following clauses are in the appropriate clause of this Specification:

(a) CSA Standard designation and year of publication (Z245.20-14);

(e) nominal thickness and maximum permissible thickness of the coating system, and individual layers if applicable; and

(g) test temperature for the flexibility test (-30, -18, or 0°C).

4.1.2 Optional Requirements

The following clauses are in the appropriate clause of this Specification:

(a) additional surface treatments;

(b) plant inspection by the purchaser;

(c) location of laboratory testing;

(d) increased test ring length;

(e) test ring location;

(f) test frequency and retest procedures;

(g) test frequency for additional test rings;

(h) additional markings;

(i) handling procedures;

(j) storage procedures;

(k) waiver of test reports;

(l) gouge test; and

(m) other special requirements.

4.3 Requirements for Quality

The Applicator shall have developed and implemented the use of a quality control program that meets the CSA Z245.20-14 requirements. The Applicator shall develop and use an Inspection and Test Plan (ITP) that covers all the requirements of CSA Z245.20-14 and this Specification. The ITP shall list each item to be inspected, the frequency of inspection, the inspection or test procedure, the acceptance criteria and any other details required by the Applicator. The ITP shall also include:

- test incoming fresh and unused (virgin) abrasives for contamination
- fresh or unused acid content
- test bare pipe surface for contamination such as salt
- test recycled and fresh abrasive mixtures for contamination and percent fines
- test abrasive blast cleaned pipe surface for particulate contamination (be specific about particulate contamination)
- type, dimensions and location of separators on pipe (see Clause 10.1.4 in this Specification)
- See Clause 6.2.2.6 in this Specification

For every order, the finalized ITP for each powder to be applied shall be submitted to the Responsible Engineer for review and written acceptance prior to coating commencing. The quality program, the ITP and the Applicator's inspection and/or test procedures referenced in the ITP shall be available at the coating Applicator's facilities and shall be available for review by the Company.

5 MATERIALS

5.1.2 Bare pipe surfaces shall be tested for salt or chloride contamination. Pre-conditioning of the bare pipe shall be applied when directed by the Company.

5.2.1 General

(b) (viii) The qualified minimum flexibility test temperature shall be -30°C (-20°F).

5.2.2 Properties

(a) System 2B and System 2C

The corrosion coating powder shall meet the requirements of CSA Z245.20-14 Table 1.

5.3 Company Approved FBE Powders

Only System 1A and System 2B FBE powders that have been approved and tested in accordance with this Specification and have been applied by an approved Applicator and application facility shall be used. The System 1A tests must pass before the System 2B results will be accepted. For System 2C, once the System 1A tests pass, the Applicator can apply System 2C FBE.

6 COATING APPLICATION

6.1.2.2 The surface profile depth, measured from peak to trough, shall be a minimum of 50 µm (2 mils) and shall not exceed 110 µm (4.5 mils).

6.1.3 Coating Qualification Test Requirements

The powder manufacturer certifications for CSA Z245.20-14 Table 2 and Table 6 shall include a statement that surface pre-treatments were not performed on any test specimens after grit blasting and before coating.

(a) System 1A

CSA Z245.20-14 Table 2, the flexibility test temperature shall be -30°C (-20°F).

(b) System 2B and System 2C

CSA Z245.20-14 Table 6, the flexibility test temperature shall be -30°C (-20°F), the impact resistance shall be 3.0 J, and the holiday detection voltage shall be at least 5 volts per µm (125 V/mil) of the test specimen coating thickness to a maximum of 5000V.

6.2.2.3 The surface profile depth, measured from peak to trough, shall be a minimum of 50 µm (2 mils) and shall not exceed 110 µm (4.5 mils). If these values fall outside the powder manufacturer's suggested range, the Applicator shall notify the Company before coating commences so an acceptable minimum, nominal and maximum surface profile depth can be specified.

6.2.2.6 A phosphoric acid surface treatment shall be applied to the external surfaces of each abrasive blast cleaned pipe in accordance with the acid wash manufacturer's recommended procedure. The acid solution shall be applied evenly and, after sufficient reaction time, rinse water shall be used to remove the acid solution and by-products.

The Applicator's ITP shall include, but shall not be limited to:

- acid manufacturer's name and product code
- acid manufacturer's recommended procedure
- residual magnetism of pipe
- conductivity of mix water, solution concentration range to be applied and determining mix concentration
- pipe surface temperature range at time of acid application and minimum acid contact times before rinsing
- conductivity of the rinse water (maximum 35 µS)
- total dissolved solids of the rinse water (maximum 20 ppm)
- rinse water pressure (minimum 1,500 psi)
- pipe pH after rinsing (6 to 7.5)

6.2.3 Application and curing temperatures shall be in accordance with the powder manufacturer's recommendations.

6.2.3.1 Virgin powder

(a) System 1A

At least 150 µm (6 mils) of coating thickness shall be virgin FBE powder as measured from the pipe surface. Thereafter, recycled and virgin mixed FBE powder may be applied within the powder manufacturer's recommended levels.

(b) System 2B

- Corrosion coating layer: At least 150 µm (6 mils) of coating thickness shall be virgin FBE powder as measured from the pipe surface. Thereafter, recycled and virgin mixed FBE powder may be applied within the powder manufacturer's recommended levels.
- ARO: The first layer of abrasion coating may contain recycled abrasion powder within the powder manufacturer's recommended levels. Virgin abrasion powder shall be used for at least the final 150 µm (6 mils) of the abrasion coating thickness.

(c) System 2C

Corrosion coating layer: At least 150 µm (6 mils) of coating thickness shall be virgin FBE powder as measured from the pipe surface. Thereafter, recycled and virgin mixed FBE powder may be applied within the powder manufacturer's recommended levels.

6.2.4 Coating Thickness

6.2.4.1 Thickness requirements

(a) System 1A

The coating thickness shall be 355 µm (14 mils) minimum, 405 µm (16 mils) nominal, and 510 µm (20 mils) maximum.

(b) System 2B

The minimum corrosion coating thickness shall be 355 µm (14 mils) and the minimum abrasion coating thickness shall be 405 µm (16 mils). The total coating thickness shall not exceed 1015 µm (40 mils). The nominal corrosion and abrasion coating thickness shall be 865 µm (34 mils). For rocky or aggressive soil conditions, a thicker ARO coating or the application of external liquid coating systems shall be considered. Consult the Responsible Engineer for any coating thickness issues.

(c) System 2C

The corrosion coating thickness shall be 460 µm (18 mils) minimum and 535 µm (22 mils) maximum. The anti-slip overcoat thickness shall be 50 µm (2 mils) minimum and 100 µm (4 mils) maximum.

7 INSPECTION AND TESTING

7.1 Inspection Notice

The Company, with or without providing the Applicator advanced notice, may inspect the handling, coating process, storage, shipping, and/or witness testing provided all applicable Company and Applicator Health, Safety and Environment (HSE) procedures are followed. The Inspectors shall have access at all times to all work related to the coating application process, with the right to inspect work and material furnished by the Contractor. All such work shall be subject to the approval of the Inspectors. Failure of the Inspectors to identify or reject defective work or materials shall not be construed as acceptance of such work or materials.

7.3.1.1 Preparation, testing and evaluation shall be at the location of coating application.

7.3.1.4

(a) System 1A

CSA Z245.20-14 Table 3, the following additional test shall be conducted: 1.5° flexibility test, CSA Z245.20-14 Clause 12.11, -30°C (-20°F) test temperature, three (3) test specimens, with no cracking and/or no stretch or stress marks.

(b) System 2B and 2C

Tested per CSA Z245.20-14 Table 7, 3.0 J impact test, holiday detection voltage of at least 5 volts per µm of the minimum total coating thickness specified, to a maximum of 5000 V.

7.3.2.1 General

All monitoring, measuring and inspection equipment shall be calibrated and accurate for the range. Heat melt crayons shall not be used for temperature measurements. The inspections and measurements required by CSA Z245.20-14 and Clauses 7.3.2.2 to 7.3.2.14 shall be made by the Applicator.

7.3.2.3 Surface Profile

Replicating film shall not be used on surfaces that are over 65°C (150°F). Where the surface temperature is over 55°C (130°F), the replicating film shall be allowed to air cool for at least two (2) minutes prior to measuring the surface profile. One measurement shall be on the pipe surface and one measurement shall be on a raised weld (where one exists).

7.3.2.7.1.1 Five (5) thickness measurements shall be made on each pipe with a coating thickness gauge for which the calibration has been verified within the last four (4) hours to NIST traceable standards. One of the measurements must be within 1.5 meters of the end of the pipe. The minimum and maximum measured total coating thickness for each pipe must be recorded.

On each pipe, one of the five measurements shall be on a raised weld (where one exists).

7.3.2.7.1.2 The thickness of each individual layer must be recorded at least once every four (4) hours per working shift.

7.3.2.7.2.1 System 1A

Where individual measured thickness values are less than the minimum specified value (Clause 6.2.4.1(a) in this Specification), the coating thickness of the affected pipe shall be measured along the pipe length at intervals not exceeding 1 m.

The average of such measured values for each pipe shall be at least 355 µm (14 mils), and no individual value shall be below 305 µm (12 mils).

Where individual measured thickness values are greater than 510 µm (20 mils), the coating thickness of the affected pipe shall be measured at intervals along the pipe length not exceeding 1 m. The average of such measured values for each pipe shall not exceed 510 µm (20 mils), and no individual value shall exceed 610 µm (24 mils).

7.3.2.7.2.2 System 2B and System 2C

Any individual or total coating thickness below the minimum thickness specified in Clause 6.2.4.1(b) in this Specification is not acceptable. The Company may or may not accept pipe where the maximum total coating thickness is exceeded. Where requested by the Company, for pipe exceeding the total maximum thickness, at the

Applicator's expense (pipe, coating and testing), the Applicator shall perform Company specified coating testing to determine its acceptability.

7.3.2.8.1.1 An additional holiday device shall be used for a second inspection of any raised welds. The Company is not responsible for holidays caused by imperfections, such as steel slivers and weld gassing. The Applicator and pipe manufacturer shall implement procedures to bring the number of repairs in-line with the repair rate typical for pipe without these imperfections.

7.3.2.8.2.2 For pipe with a 355.6 mm OD or larger (≥ 355.6 mm), the acceptance criteria is less than or equal to 0.35 holidays per square metre (≤ 0.35/m^2), determined by dividing the total number of holidays by the total outside surface area for the individual pipe tested.

7.3.2.8.2.4 Hand flocking shall not be permitted.

7.3.2.11 The surface temperature and dew point values from CSA Z245.20-14 Clause 6.2.2.2 shall be recorded at least every two (2) hours.

7.3.2.12 The phosphoric acid surface treatment values from Clause 6.2.2.6 in this Specification shall be recorded at least every two (2) hours.

7.3.2.13 The Applicator shall provide records of the powder batch number applied to each pipe or the batch numbers applied to each shift.

7.3.2.14 The cut back shall be monitored and controlled within the limits of CSA Z245.20-14 Clause 6.2.5. These values shall be recorded at least every two (2) hours.

7.3.3.1 Facilities

The Applicator shall perform all Type A and Type B tests at the place of coating application per CSA Z245.20-14 Table 4 and Table 8.

7.3.3.2 Test Rings

Each test ring shall be no more than 500 mm (20 in.) long and located at least 300 mm (12 in.) from a pipe end. On all cut pipe, the pipe shall be bevelled to match the requirements of the applicable pipe standard (see Company purchase order). The cutback area of the test ring may be coated.

7.3.3.3.1

(a) System 1A

The Company may select the pipe for testing.

(b) System 2B and System 2C

A corrosion coating test ring shall also be taken every working shift. See Clause 7.3.3.4.1 and Clause 7.3.3.4.2 in this Specification for the retest procedure for the corrosion coating. The Company may select the pipe for testing.

7.3.3.3.2 One test ring shall be prepared for testing every working shift or every 24 hours.

7.3.3.3.3

(a) System 1A

The coating shall meet the requirements of CSA Z245.20-14 Table 4 and the following:

- 24 hr cathodic disbondment at 65°C (150°F): where the radius of disbondment is in excess of 5.5 mm maximum average radius, the cause shall be investigated by the Applicator and reported to the Company
- 2.5° flexibility test temperature: -30°C (-20°F) with no cracking
- interface contamination: Type A test
- the following additional Type A test shall be conducted: 1.5° flexibility test, CSA Z245.20-14 Clause 12.11, -30°C (-20°F) test temperature, three (3) test specimens, and no cracking and/or no stretch or stress marks

(b) System 2B and System 2C

The corrosion coating test ring shall meet the requirements for System 1A in Clause 7.3.3.3.3(a) of this Specification.

The coating system test ring shall meet the requirements of CSA Z245.20-14 Table 8 and the following:

- 24 hr cathodic disbondment at 65°C (150°F): acceptance criteria is 4.5 mm maximum average radius
- 2.5° flexibility test temperature: -30°C (-20°F) with no disbonding and no cracking and/or no stretch or stress marks
- 24 hr adhesion: rating of 1-3
- 3.0 J impact resistance: holiday tested at 5 volts per μm (125 V/mil) of the test ring coating thickness, to a maximum of 5000V
- the following additional Type A test shall be conducted: 1.5° flexibility test, CSA Z245.20-14 Clause 12.11, -30°C (-20°F) test temperature, three (3) test specimens, no cracking, no stretch or stress marks, no separation of the corrosion coating from the steel or tearing apart of any coating layer (cohesive).

7.3.3.4 Retests

7.3.3.4.1 Adhesion and 24 hour cathodic disbondment retests shall meet the requirements of Clause 7.3.3.3.3(a) or Clause 7.3.3.3.3(b) of this Specification, as appropriate.

7.3.3.4.2 This clause is applicable to coating System 1A, 2B and 2C corrosion coating retests. For an agreed retest frequency, samples of the 2B and 2C corrosion coating may be obtained by hand filing off the abrasion coating and anti-slip overcoat to expose the corrosion coating, or by an Applicator procedure accepted by the Company.

8 REPAIR OF COATED PIPE

8.2 Holiday repairs (see Table 9)

(d) Melt sticks are not permitted. All holidays less than or equal to 2 mm maximum diameter or width shall be repaired with two-part epoxy or a Company approved equivalent.

(e) All repairs shall be made with a Company approved cartridge or with a brush grade material with a coating thickness of 510 µm to 890 µm (20 mils to 35 mils) over steel. The approved materials are as follows (listed in alphabetical order):

- Denso North America Inc.: Protal 7200 or 7250
- Specialty Polymer Coatings Inc.: SP-2888 R.G.
- Specialty Polymer Coatings Inc.: SP-3888
- 3M: Scotchkote 327

For all repairs to System 2B, the thickness over steel shall be 890 µm to 1145 µm (35 mils to 60 mils).

For all repairs to System 2C, the thickness over steel shall be 510 µm to 890 µm (20 mils to 35 mils).

(f) Repair materials shall be applied and cured in accordance with the manufacturer's requirements. Cure temperatures shall be continuously above 10ºC until the manufacturer's curing requirements are met. For two-part repairs ≤ 2.0 mm across, the repair materials shall overlap the roughened, cleaned and sound coating by at least 25 mm. For two-part repairs > 2.0 mm and ≤ 160 mm across, the repair material shall overlap the roughened, cleaned and sound coating by at least 50 mm. All roughened coating shall be coated over.

(g) Coating thicknesses shall be per Clause 8.2(e) of this Specification.

(j) Repairs of the cutback section on pipe ends shall be completed with Company approved two-part materials. The repair materials shall be applied and cured in accordance with the manufacturer's requirements. Cure temperatures shall be continuously above 10°C until the manufacturer's curing requirements are met. The area to be repaired shall not exceed 250 cm^2.

9 MARKINGS

9.2.1

(g) For additional markings, refer to the Company purchase order. A legible and unique pipe identifier shall be paint applied onto the coating on the outside wall at each end of the pipe. Prior to coating application, the Applicator shall submit a marking template/map to the Company for acceptance that includes all the information to be applied onto the coating.

10 HANDLING AND STORAGE

The Applicator shall be responsible for any damage occurring to the pipe and/or the coating from unloading to shipping.

10.1.1 The applicable documents shall be at the place of coating application and shall be available to the Company.

10.1.4 Where the separators are affixed to the coated pipe, the affixing material shall minimize the covering of any markings, and the affixing material shall be at least 100 mm (4 in.) from the edge of the coating. The type, dimensions, method of affixing the separators and location of separators on the pipe shall be as per the ITP (see Clause 4.3 in this Specification).

10.2 The Applicator shall submit details of the facilities and the methods to be used for yard storage.

The applicable documents shall be at the place of coating application and shall be available to the Company.

When FBE coated pipe is to be stored for more than twelve (12) months, contact the Responsible Engineer to determine the appropriate coating material to be used to protect the FBE coating from ultraviolet (UV) degradation.

11 TEST REPORTS AND CERTIFICATES OF COMPLIANCE

11.1 The Inspection and Test Plan (ITP), the powder manufacturer's certifications and all test reports shall be submitted to the Company. Refer to CSA Z245.20-14 and Clause 4.3 (ITP), Clause 5.2.1, Clause 5.2.2, and Clause 6.1.3 in this Specification.

11.2 Certificates of compliance shall be submitted to the Company.

12 TEST PROCEDURES

12.8.3.3 The electrolyte solution shall not be replaced at 7 days, 14 days or 21 days during the 28-day testing period.

12.11 Flexibility of the Coating

12.11.3.1 All flexibility tests shall be done at -30°C (-20°F). The bend tester to be used shall hold each flexibility test sample by one end and push it upwards against a cylindrical steel stop. Refer to Appendix A of this specification for photographs of the bend testing equipment to be used.

12.12 Impact Resistance of the Coating

12.12.3 Procedure

(f) System 2B and System 2C

The holiday detection voltage shall be 5 V/µm (125 V/mil) of the minimum total coating thickness specified.

12.15 Gouge Resistance of the Coating

12.15.2 Equipment

The equipment shall consist of the following:

(a) a moveable cart under a fixed point with the following features:

i. an electric motor and a screw drive mechanism to move the cart;

ii. a point that can be loaded with weights to any desired level up to approximately 100 kg;

iii. a replaceable Fullerton R-33 double-cut carbide burr with an angle cone point terminating in a hemispherical tip purchased from Discount Tools (Part Number 48252); and

iv. refer to Appendix B of this Specification for a photograph of the equipment to be used.

12.15.3 Test Specimens

Laboratory-coated test specimens will be cut from a coated pipe sample. The circumferential cuts must be perpendicular to the axis. Specimens can measure 25 mm to 155 mm (1 in. to 6 in.) in width and 100 mm to 255 mm (4 in. to 10 in.) in length, with a combined pipe wall and coating thickness of up to 25 mm (1 in.).

12.15.4 Procedure

(a) Three (3) test specimens with one (1) gouge test per specimen at test temperatures of -30°C ± 3ºC and 50°C ± 5ºC at a specified load of 30 kg.

(b) Secure the specimen. Use both the weight winch and the arm winch in tandem to adjust the height of the lever arm. The arm will tilt only a few degrees before the counter weights come in contact with the vertical frame members of the pivot rod tower.

(f) Adjust the position of the clamp light to properly light the test specimen area and contact point.

(g) Mark the test specimen with a series of dots at least 0.5 in. apart at the right edge of the selected test area. Place the specimen so that it contacts the backing block. Stack support plates or bars under the specimen until the coating surface of the test specimen is near the level of the top of the backing block. Adjust the position of the cart until the contact point is located over the right end of the specimen in the selected test area and is aligned with one of the marks.

(h) Perform the following steps:

ii. Perform the test by pushing the directional control switch in the forward test direction (right). Hold the switch until the cart traverses the desired distance, then release the switch. The switch will spring back to its normal “off” position and the motor will stop. Confirm that the contact point remains within the coated area of the test specimen and at least 0.5 in. from the edge of the specimen. Do not allow the contact point to touch the backing block or clamp bar.

Table 12-1: Company pre-qualification testing of coating and application facility for coating System 1A (Replaces CSA Z245.20-14 Table 2)#

Test	Number of test specimens	CSA Z245.20-14 Test Method Clause	System 1A Acceptance Criterion
24 h cathodic disbondment @ 65°C, 3.5 V	3	12.8	4.5 mm maximum average radius on each specimen *
48 h cathodic disbondment @ 65°C, 1.5 V	3	12.8	4.5 mm maximum average radius *
14 day cathodic disbondment @ 65°C, 1.5 V	3	12.8	11.5 mm maximum average radius *
28 day cathodic disbondment @ 20°C, 1.5 V	3	12.8	7.0 mm maximum average radius +
28 day cathodic disbondment @ 50°C, 1.5 V	3	12.8	11.5 mm maximum average radius *
28 day cathodic disbondment @ 65°C, 1.5 V	3	12.8	13.5 mm maximum average radius *
28 day cathodic disbondment @ 80°C, 1.5 V	3	12.8	16.5 mm maximum average radius *
Cross section porosity	3	12.10	Rating 1-4
Interface porosity	3	12.10	Rating 1-4
2.5° flexibility @ -30°C	3	12.11	No cracking
1.5° flexibility @ -30°C	3	Clause 7.3.3.3.3 and 12.11 of this Specification	No cracking or no stretch or stress marks
1.5 J impact resistance @ -40°C, -30°C, -10°C, 0°C, 20°C and 50°C	3 at each temperature	12.12	No holidays
Thermal characteristics	3	12.7	CSA Z245.20-14 Table 1 and Table 4
Adhesion: 24 h @ 75°C and 95°C	3 at each temperature	12.14	Rating 1-3 on each specimen
Adhesion: 48 h @ 75°C	3	12.14	Rating 1-3 on each specimen
Adhesion: 28 days @ 75°C and 95°C	3 at each temperature	12.14	Rating 1-3 on each specimen

Note:

* The average for each specimen is determined and the three (3) averages are averaged to determine if the acceptance criterion is met.

+ No individual reading shall exceed 8.0 mm.

Any qualification re-tests to be completed will be at the discretion of the Company.

Table 12-2: Company pre-qualification testing of coating and application facility for coating System 2B and 2C (Replaces CSA Z245.20-14 Table 6)#

Test	Number of test specimens	CSA Z245.20-14 Test Method Clause	System 2B & 2C Acceptance Criterion
24 h cathodic disbondment @ 65°C, 3.5 V	3	12.8	4.5 mm maximum average radius *
48 h cathodic disbondment @ 65°C, 1.5 V	3	12.8	4.5 mm maximum average radius *
28 day cathodic disbondment @ 20°C, 1.5 V	3	12.8	6.5 mm maximum average radius on each specimen
28 day cathodic disbondment @ 65°C, 1.5 V	3	12.8	13.5 mm maximum average radius *
28 day cathodic disbondment @ 80°C, 1.5 V	3	12.8	16.5 mm maximum average radius *
Cross section porosity	3	12.10	Rating 1-4
2.5° flexibility @ -30°C	3	Clause 7.3.3.3.3 and 12.11 of this Specification	No disbondment from steel and no cracking and/or no stretch or stress marks
1.5° flexibility @ -30°C	3	Clause 7.3.3.3.3 and 12.11 of this Specification	No cracking and/or no stretch or stress marks
3.0 J impact resistance @ -40°C, -30°C, -10°C, 0°C, 20°C and 50°C	3 at each temperature	12.12	No holidays
Thermal characteristics	3	12.7	CSA Z245.20-14 Table 5 and Table 8
Adhesion: 24 h @ 75°C and 95°C	3 at each temperature	12.14	Rating 1-3 on each specimen
Adhesion: 48 h @ 75°C	3 at each temperature	12.14	Rating 1-3 on each specimen
Adhesion: 28 d @ 75°C and 95°C	3 at each temperature	12.14	Rating 1-3 on each specimen
Gouge test at -30°C and 50°C	3 at each temperature	Clause 12.15 of this Specification	Maximum penetration depth of 508 μm (20 mils)

Note:

* The average for each specimen is determined and the three (3) averages are averaged to determine if the acceptance criterion is met.

Any qualification re-tests to be completed will be at the discretion of the Company.

13 VARIANCES

Any deviation shall follow the Company Management of Change (MOC) Variance Procedure (EDMS No. 7728702). External vendors must contact the Company Responsible Engineer or another authorized Company representative for variance approval.

14 ROLES AND RESPONSIBILITIES

Table 14-1 lists the roles and responsibilities required for the use of this Specification.

Table 14-1: Roles and Responsibilities

Role	Responsibilities
Applicator	The Applicator is responsible for ensuring that the proper method is used to apply the FBE materials to the appropriate surface area.
Company Coating Inspector	The Company Coating Inspector is responsible for ensuring that the Applicator uses the proper method to apply the FBE materials to the appropriate surface area, and that the result meets the standards set forth by the Company in this Specification.
Responsible Engineer	The Responsible Engineer is accountable for ensuring that the plan set forth by the Applicator meets the standards set forth by the Company, and that resolution to any questions that arise from the use of this Specification meets the standards set forth by the Company.
Manufacturer	The Manufacturer is responsible for ensuring that the product produced for application is produced in accordance with the documentation that it provides to the Applicator.

15 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are listed in Table 15-1, Table 15-2 and Table 15-3. Use the latest document revision, unless otherwise approved by TransCanada.

Table 15-1: Regulatory References

Organization/Document No.	Title
Canadian Standards Association (CSA)	CSA Z245.20-14 Plant-applied external fusion bond epoxy coating for steel pipe
	CSA Z662 Oil and Gas Pipeline Systems
U.S. Department of Transportation (DOT), Code of Federal Regulations (CFR)	DOT 49 CFR 192 Transportation of Natural and Other Gas by Pipeline
	DOT 49 CFR 195 Transportation of Hazardous Liquids by Pipeline

Table 15-2: External Industry References

Organization/Document No.	Title
National Association of Corrosion Engineers (NACE) International	NACE SP 0394 Application, Performance, and Quality Control of Plant-Applied Single Layer Fusion-Bonded Epoxy External Pipe Coating

Table 15-3: Internal References

Document No.	Title
For this Specification, there are no specific Internal References	

16 DOCUMENTATION AND RECORDKEEPING

All technical document submittal requirements are provided in the Vendor Technical Document Requirements List (VDRL) included with the proposal request or purchase order.

Due to the broad range of data types that may be required in support of this Specification, there are a number of repositories that may need to be utilized for documentation purposes. A summary of key data repositories appears in Table 16-1.

Table 16-1: Documentation Requirements

Documentation Description	Repository / Link
Quality Documentation	Project Records
Test Reports and Certificates of Compliance	Project Records

17 DOCUMENT HISTORY

Rev.		
09	**Description**	**Effective Date**
	This document is the new version of TES-COAT-FBE, updated in accordance with the CPG Integration.	2017-Aug-01
	Rationale Statement	**Responsible Engineer**
	This document was developed / revised in order to address the following requirements: • CPG Integration	Aissa Van Der Veen, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to integrate the TransCanada and CPG documents.	Aissa Van Der Veen, P. Eng.
Rev.		
08	**Description**	**Effective Date**
	This document is the new version of TES-COAT-FBE, updated in accordance with the documentation Streamlining initiative.	2016-Nov-08
	Rationale Statement	**Responsible Engineer**
	This document was developed / revised in order to address the following requirements: • Streamlining of content to reflect the updated document collection of the coatings department	Aissa Van Der Veen
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Coatings group and to make it more easily accessible to those who use it.	Aissa Van Der Veen

18 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
Update format and content	As a part of the Streamlining and Simplification process, this document has been reformatted and updated to reflect TransCanada template.

19 APPROVALS

APPROVALS		
Originator: Aissa Van Der Veen, P. Eng. Welding and Materials Engineering	Signature	JUNE 27, 2017 Date
Reviewer: Daniel Herpin, Manager Corrosion Services	D. Herpin Signature	June 27, 2017 Date
Reviewer: Niteesha Falcon, P. Eng. Welding and Materials Engineering	Niteesha Falcon Signature	June 27, 2017 Date
Responsible Engineer: Aissa Van Der Veen, P. Eng. Welding and Materials Engineering	Signature JUNE 27, 2017 Date	PROFESSIONAL ENGINEER ALBERTA AISSA VAN DER VEEN APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, P. Eng., Manager Welding and Materials Engineering	Signature	June 27, 2017 Date

APPENDIX A PHOTOGRAPHS OF BEND TESTING EQUIPMENT

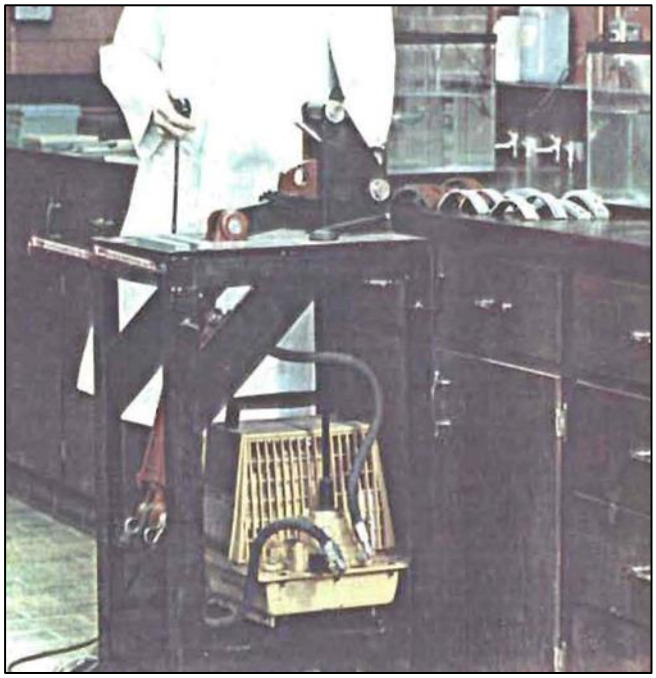

Figure A-1: Bend Testing Equipment

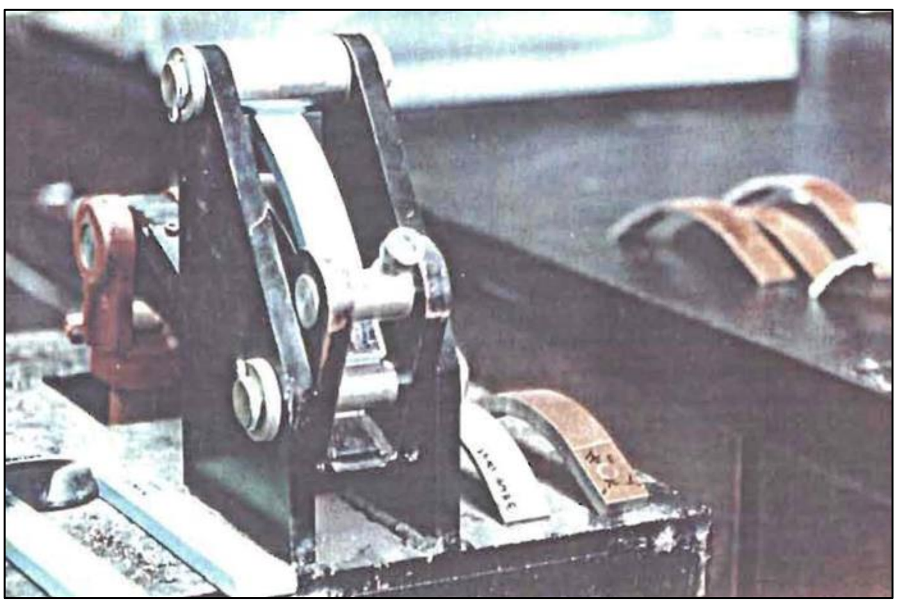

Figure A-2 Close-Up of Bend Testing Equipment

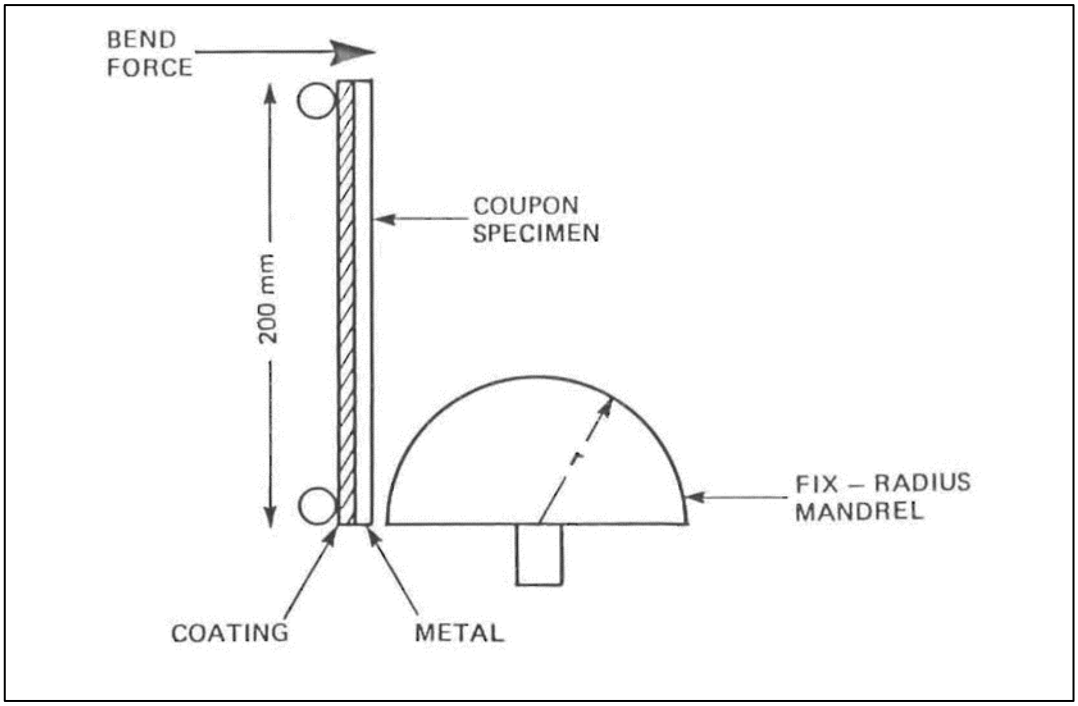

Figure A-3 Mandrel Diagram

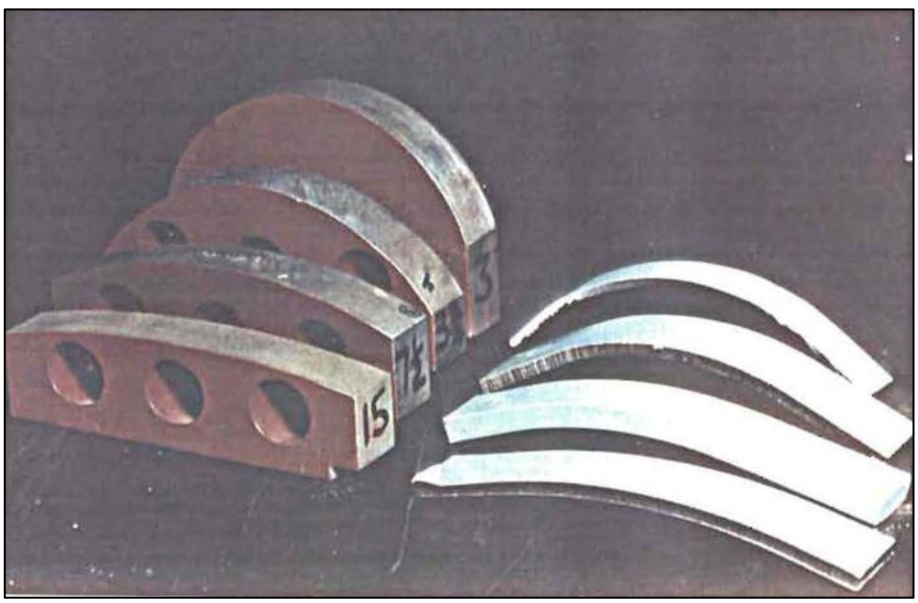

Figure A-4 Mandrels

Figure A-5: Bend Test Perspective 1

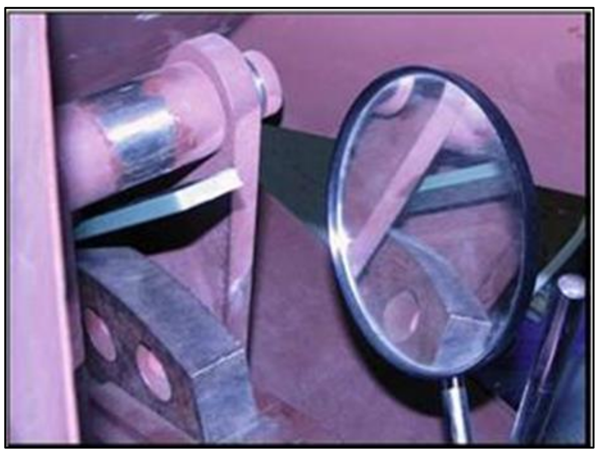

Figure A-6: Bend Test Perspective 2

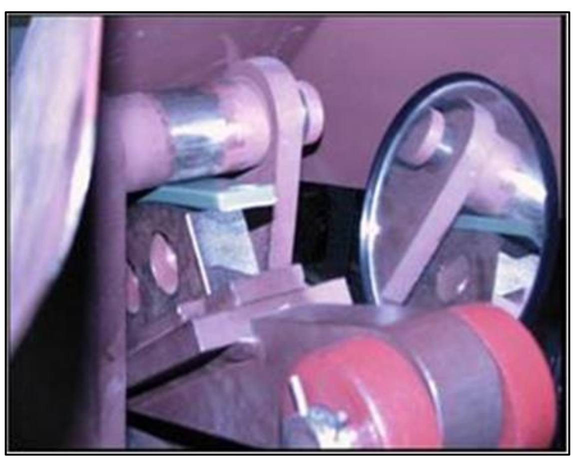

Figure A-7: Bend Test Perspective 3

Figure A-8: Top View of Bend Testing Equipment

APPENDIX B PHOTOGRAPHS OF GOUGE TESTING EQUIPMENT

Figure B-1: Gouge Testing Equipment

PURPOSE

This Standard provides key requirements for the non-destructive examination (NDE) of the welding of pipe and components, by identifying the applicable Specifications(s) and/or Procedure(s).

SCOPE / APPLICABILITY

This Standard details the NDE Techniques used by the Company, their considerations for application and reporting requirements. This standard refers to the NDE of welds completed on pipe and piping components for new construction, maintenance, and repairs of existing facilities and examination conducted either in-plant, in-shop, or in-field. Each Specification and/or Procedure referenced in this document covers the minimum requirements for examination and review of examination results.

This Standard also applies to all pipelines, pipeline components, and facilities in Canada, the United States (U.S.), and Mexico.

This Standard applies to TransCanada's NDE program as it relates to the following techniques:

- Ultrasonic (UT)
  - Manual Ultrasonic Examination (UT/MUT)
  - Automated Ultrasonic Examination (AUT)
  - Phased Array Examination (PA)
- Radiographic Examination (RT) including X-Ray, Gamma, Computed (CR) and Digital (DR)
- Magnetic Particle (MT)
- Liquid Penetrant (PT)
- Visual Examination (VT)

The Responsible Engineer shall be contacted for clarification if needed.

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1 CONTENT FRAMEWORK

The content framework in Figure 1-1 provides the general structure for the material as applicable to this Standard. This framework represents the key requirement categories outlined in Section 2.

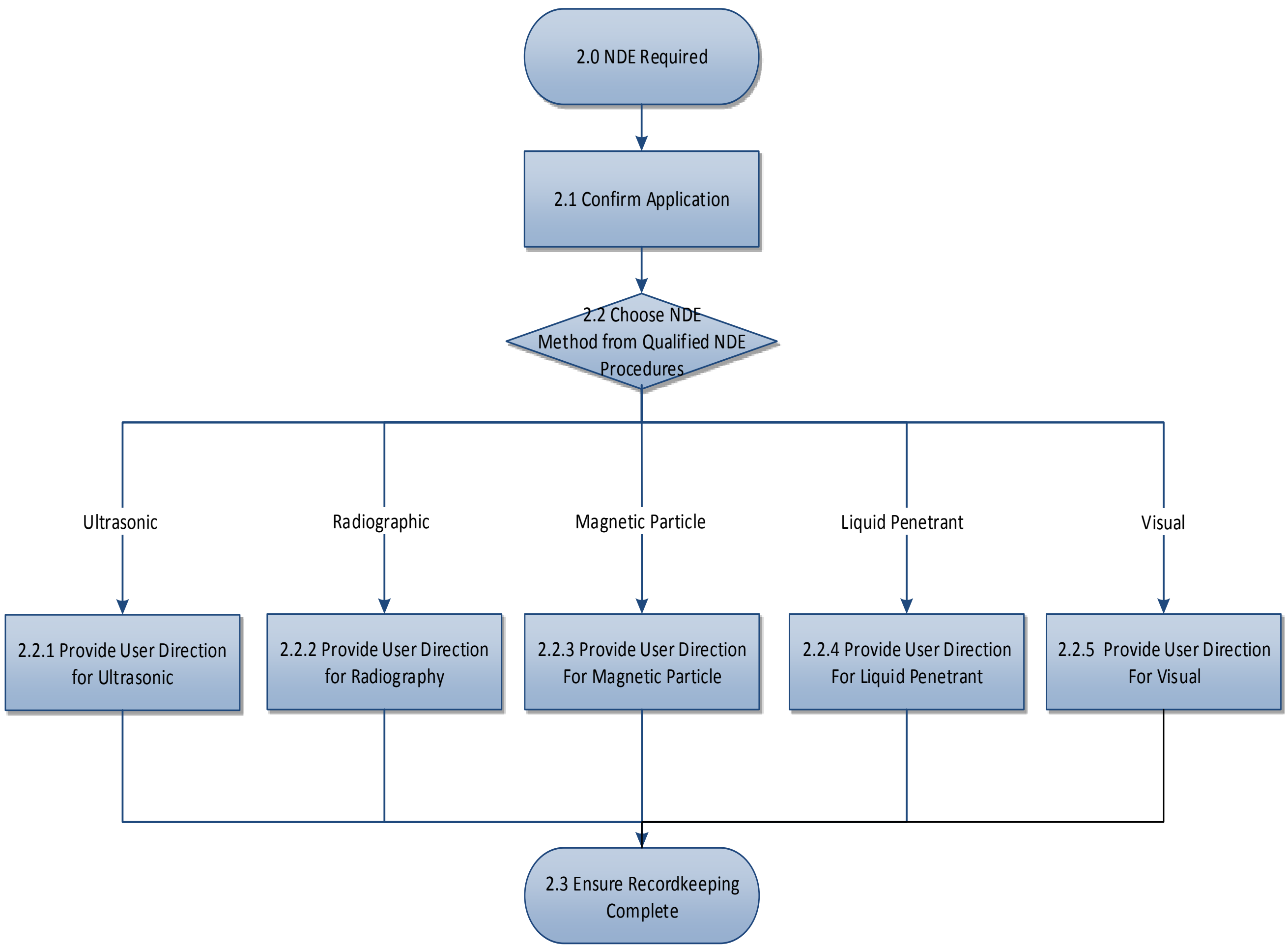

Figure 1-1: Content Framework

2 NDE REQUIREMENTS

The process outlined in this Standard is initiated when the need for non-destructive examination of welding is identified.

2.1 Confirm Application

A qualified individual will select the NDE technique based on five primary factors:

- Location of NDE application (see Table 2-1)
- The nature and type of the weld (see Table 2-2)
- The NDE method considerations (see Table 2-3)
- The scope of the project (described in the following tables)

The type of application determines the most appropriate NDE type. Table 2-1 defines the NDE type and corresponding application location.

Table 2-1: Allowable NDE Methods Based on Application

Application	Ultrasonic Examination (UT)	Automated Ultrasonic Examination (AUT)	Radiographic Examination (RT)[1]	Magnetic Particle Examination (MT)	Liquid Penetrant Examination (PT)	Phased Array (PA)	Visual Examination (VT)
Fabrication, Shop	✓[2]	X	✓	✓	✓[4]	✓[5]	✓
Fabrication, Field	✓[2]	X	✓	✓	✓[4]	✓[5]	✓
Facility	✓[2]	✓[3]	✓	✓	✓[4]	✓[5]	✓
In-Service Welding	✓	X	✓	✓	✓[4]	✓[5]	✓
Pipeline	✓	✓	✓	✓	✓[4]	✓[5]	✓

Notes:

[1] Includes Computed Radiography (CR) and Digital Radiography (DR).

[2] Not typically utilized as a standalone application, more of a supplementary method as needed.

[3] AUT shall only be utilized on known pipe materials which calibration blocks have been created for. Pipe to pipe applications only.

[4] PT Inspection shall be utilized in place of MT for stainless steel applications.

[5] PA inspection requests shall be subject to conditions and approval by Materials and Welding Engineering.

2.2 Choose NDE Method from NDE Specifications

The most appropriate type of NDE is then determined according to the nature and type of the weld. Table 2-2 defines the typical primary NDE techniques (or combination of) for different weld techniques.

Table 2-2: NDE Determination Method

Welding Technique	Typical Primary NDE Method	Possible Combinations
Gas Metal Arc Welding (GMAW)	• UT (AUT only) • Do not use AUT in a fabrication shop	• Supplement AUT with MUT, MT and RT, depending on the project scope (pipeline to facility)
Shielded Metal Arc Welding (SMAW)	• AUT is the preferred application if large (over 15 km) quantities of welds require examination and wall thickness is greater than 6.4 mm (0.250 in) • RT is the preferred application if small (under 15 km) quantities of welds require examination or wall thickness is below 6.4 mm (0.250 in)	• Use AUT or RT in combination with MT and MU, depending on the project scope (pipeline to facility)
Flux Cored Arc Welding (FCAW)	• AUT is the preferred application if large (over 15 km) quantities of welds require examination and wall thickness is greater than 6.4 mm (0.250 in) • RT is the preferred application if small (under 15 km) quantities of welds require examination or wall thickness is below 6.4 mm (0.250 in)	• Use AUT or RT in combination with MT and MU, depending on the project scope (pipeline to facility)

In order to choose the correct combination of NDE methods, it is important to be aware of the pros and cons for each method, as well as the type of anticipated anomalies.

Table 2-3 defines some of the considerations.

Table 2-3: NDE Method Considerations

NDT Type	Pros	Cons
AUT	• Provides through-thickness position and the dimensions of imperfections in the vertical and circumferential plane • Most economic process for heavier wall, larger diameter pipe • Recorded and auditable inspection data • Most effective technique for planar weld flaws (lack of fusion and cracks) • Instant results enabling immediate weld quality assessment • High productivity able to match construction production rates • Can work within any vicinity of public and or workers	• Considerable cost and time required for initial setup • Limited to wall thicknesses greater than 6.4 mm (0.250 in.) for factory bevels and 7.2 mm (0.283 in.) for GMAW bevels • Highly trained technicians required to perform the work • Weld preparation required—i.e., 10-13 cm (4-5 in) of pipe coating, weld spatter and seam removal on either side of girth weld • Specialized technique with limited approved vendors who can supply this service
MUT (supplementary process)	• Provides through-thickness position and the dimensions of imperfections in the vertical and circumferential plane • Typically, a one-man crew can perform the work	• No recorded data, limiting audit function to procedural and reporting review • Typically, only utilized as supplementary application to AUT or RT
RT (X-ray and Gamma Ray)	• Very little setup time and cost required to prepare for a project • Application can be made by most Company approved NDE vendors • Recorded and auditable inspection data allow for good detection of volumetric flaws	• Cannot provide through-thickness dimensions of imperfections • Circumferential positioning and flaw classification only • Significantly reduced productivity as the weld thickness increases or if the weld is inspected externally • Cannot achieve instant results due to process, safety, and proximity limitations • Health and safety risks associated with use of radiation • Overlooked associated consumables can add up to significant additional costs • Storage costs for film developed throughout a project are significantly higher than AUT data

NDT Type	Pros	Cons
Computed Radiography (CR)	• Ability to manipulate image resolution compared to standard radiography • Digital files enable remote third party reviews of films if required • Good for detecting volumetric flaws • Reduced film costs	• Health and safety risks associated with use of radiation • Cannot achieve instant results due to process, safety, and proximity limitations • Cannot provide through-thickness dimensions of imperfections • Circumferential positioning and flaw classification only • Significantly reduced productivity as the weld thickness increases or if the weld is inspected externally • Approval and assessment required by the Company prior to implementation
Digital Radiography (DR)	• Fastest RT method • Ability to manipulate image resolution compared to standard radiography • Digital files enabling remote third party reviews of films if required • Good for detecting volumetric flaws • Reduced film costs • Reduced radiation exposure in comparison to standard RT methods • Increased productivity in comparison to other RT applications	• Currently only applicable to pipeline construction projects • Health and safety risks associated with use of radiation • Cannot achieve instant results due to process, safety, and proximity limitations • Cannot provide through-thickness dimensions of imperfections • Circumferential positioning and flaw classification only • Typically, a cumbersome piece of equipment, which could limit tight space applications • Approval from Materials and Welding Engineering required prior to use
MT/MPI	• Ideal for surface and surface breaking flaws • Rapid and easy to interpret	• Cannot easily detect buried flaws • Cannot detect depth of flaws • Limited to specific weld inspection applications as defined in Company Specifications
PT/LPI	• Good for surface breaking flaws • Rapid and easy to interpret	• Cannot detect buried flaws • Cannot detect depth of flaws • Limited to specific weld inspection applications as defined in Company Specifications

NDT Type	Pros	Cons
PA	• Provides through-thickness position and the dimensions of imperfections in the vertical and circumferential plane • Most economic process for heavier wall, larger diameter pipe • Recorded and auditable inspection data • Most effective technique for planar weld flaws (lack of fusion and cracks) • Instant results enabling immediate weld quality assessment • Works within any vicinity of public and or workers	• High training requirement because technique requires more technical knowledge than traditional UT • Considerable time required for initial setup • Weld preparation required—i.e., 8-13 cm (3-5 in) of pipe coating, weld spatter and seam removal on either side of girth weld • Specialized technique with limited approved vendors who can supply this service • Suitable as a standalone application for pipe to pipe configurations only at this stage • Approval from Materials and Welding Engineering required prior to use
VT	• Easy to perform, simple, and does not require sophisticated equipment (fiberscopes, borescopes, magnifying glasses, and mirrors)	• Only able to detect imperfections visible to the human eye

2.2.1 User Direction for Ultrasonic Examination (UT)

There are three main UT techniques used by the Company. Table 2-4 provides the names of the Specifications used for each technique.

Table 2-4: Ultrasonic Techniques

Technique	Instructional Document
Automated Ultrasonic Examination (AUT)	• TES-NDT-UT (for Canada) (EDMS No. 1001829033) • TES-UT-API (for the US and Mexico) (EDMS No. 1001828660)
Manual Ultrasonic Examination (MUT)	• TES-NDT-UT (for Canada) (EDMS No. 1001829033) • TES-UT-API (for the US and Mexico) (EDMS No. 1001828660)
Phased Array (PA)	• TES-NDT-PA (for Canada, US and Mexico) (EDMS No. 9219103)

2.2.2 User Direction for Radiographic Examination (RT)

There are three main RT techniques used by The Company. Table 2-5 provides the names of the Specifications used for each technique.

Table 2-5: Radiographic Techniques

NDE Technique	Instructional Document
X-Ray/Gamma	• TES-NDT-RT (for Canada) (EDMS No. 3671368) • TES-RT-API (for the US and Mexico) (EDMS No. 4472888)

NDE Technique	Instructional Document
Digital Radiography (DR)	• TES-NDT-RT (for Canada) (EDMS No. 3671368) • TES-RT-API (for the US and Mexico) (EDMS No. 4472888)
Computed Radiography (CR)	• TES-NDT-RT (for Canada) (EDMS No. 3671368) • TES-RT-API (for the US and Mexico) (EDMS No. 4472888)

2.2.3 Direction for Magnetic Particle Examination (MT)

TransCanada has not identified any requirements that are incremental to CSA Z662, API 1104, or ASME, as applicable, for this Standard.

2.2.4 Direction for Liquid Penetrant Examination (PT)

TransCanada has not identified any requirements that are incremental to CSA Z662, API 1104, or ASME, as applicable, for this Standard.

2.2.5 Direction for Visual Examination (VT)

Visual examination is the responsibility of the Welding group. For information on visual examination, refer to TEP-NDT-VT Visual Examination (CDN-US-MEX) (EDMS No. 7381161).

2.3 Ensure Recordkeeping Complete

Once examination is complete, any required documentation must be updated regarding the completed NDE. This information should be added to TEP-NDT-REC Non-Destructive Examination Records Management (CDN) (EDMS No. 3749393).

3 VARIANCES

Any deviation must follow the appropriate TransCanada Management of Change (MOC) Variance Procedure (EDMS No. 7728702).

4 ROLES AND RESPONSIBILITIES

Table 4-1 outlines the roles and responsibilities required for the use of this Standard.

Table 4-1: Roles and Responsibilities

Role	Responsibilities
NDE Technician	• Responsible for the completion of the NDE and the interpretation of the results.
NDE Team within Welding and Materials Engineering	• Accountable for the examination and inspection of pipelines and pipeline components.
Welding Team within Welding and Materials Engineering	• Responsible for informing the NDE team of welding projects so that NDE can be coordinated. • Accountable for visual Inspections of welds.

5 TRAINING AND QUALIFICATIONS

Training and qualification requirements are as prescribed in applicable specifications, codes, and regulations.

6 SAFETY CONSIDERATIONS

No incremental Safety Considerations are identified for this Standard.

7 ENVIRONMENTAL CONSIDERATIONS

No incremental Environmental Considerations are identified for this Standard.

8 GLOSSARY

Definitions related to this Standard can be found in Appendix A.

9 REFERENCES

This document relies on a number of references to legislation (act, statutes, and regulations), certificates, and orders and may include directives, guidelines, standards, and codes to the extent they contain legally binding requirements for TransCanada.

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 9-1.

Table 9-1: External and Internal References

Document No.	Title
Legal Requirements	
For this Specification, there are no specific legal requirements.	
Industry Codes and Standards	
API 1104	Welding of Pipelines and Related Facilities
ASME V	Boiler and Pressure Code – Section V – Non-Destructive Examination
ASME B31.3	Gas Transmission and Distribution Piping Systems
CSA Z662	Oil and Gas Pipeline Systems
Internal References – Documents that Reference this Standard	
N/A	N/A
Internal References – Documents Referenced by this Standard	
EDMS No. 3671368	TES-NDT-RT Radiographic Examination of Welds Specification (CDN)

Document No.	Title
EDMS No. 4472888	TES-RT-API Radiographic Examination of Welds Specification (US-MEX)
EDMS No. 1001829033	TES-NDT-UT Ultrasonic Examination of Girth Welds Specification (CDN)
EDMS No. 1001828660	TES-UT-API Ultrasonic Examination of Girth Welds Specification (US-MEX)
EDMS No. 3749393	TEP-NDT-REC Non-Destructive Examination Records Management (CDN)
EDMS No. 9219103	TES-NDT-PA Phased Array & TOFD Inspections of Welds & Materials (CDN-US-MEX)

10 DOCUMENTATION AND RECORDKEEPING

Documentation created through the use of this Standard shall be indexed in the Records Management Database, and filed in accordance with TEP-NDT-REC Non-Destructive Examination Records Management (CDN) (EDMS No. 3749393). These documents may include but are not limited to: Radiographic films, Automated Ultrasonic Scans, Daily Radiographic/Ultrasonic Reports, Liquid Penetrant Examination Interpretation Reports, and Magnetic Particle Examination Interpretation Reports.

11 DOCUMENT HISTORY

Rev.		
00	**Description**	**Effective Date**
	New document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	**Responsible Engineer**
	This document was developed in order to address the following requirements: • Provide a standard for the NDE method determination process	Robert Lazor, P.Eng.
	Impact Assessment Summary	**Document Owner**
	This standard was created to streamline the documentation required for the NDE group and to make it more easily accessible to those using the underlying specifications.	Robert Lazor, P.Eng.

12 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A.
Industry Standards	
N/A	N/A.
General	
N/A	This Standard is a new document.

13 APPROVALS

APPROVALS		
Originator: Jason Althouse, Senior NDE Technologist, Welding and Materials Engineering	Signature	2016-Nov-01 Date
Reviewer: Salvatore Delisi, Senior Welding Technologist, Welding and Materials Engineering	Salvatore J. Delisi Signature	10/25/16 Date
Responsible Engineer: Robert Lazor, P.Eng., Welding and Materials Engineering	Signature 1 Nov 2016 Date	PROFESSIONAL ENGINEER ROBERT B. LAZOR ALBERTA 1 Nov 2016 APEGA Permit to Practice P7100

APPENDIX A TERMS AND DEFINITIONS

Terms	Definitions
Company	TransCanada including their engineering agencies, inspectors and other authorized representatives.
Vendor	Any outside source hired by the Company to complete work
PT (Liquid Penetrant Inspection)	A method of inspection that utilizes the capillary action of open to surface defects and is used primarily for non-ferrous materials (i.e. Stainless Steel).
MT (Magnetic Particle Inspection)	A method of inspection that uses flux leakage to detect surface and sub-surface discontinuities on ferrous materials
UT (Ultrasonic Inspection)	A method of inspection that utilizes ultrasonic waves to detect discontinuities within the materials being inspected and is hand manipulated
AUT (Automated Ultrasonic Inspection)	Automated zonal ultrasonic inspection of pipeline girth welds that records and stores data in a digital format. This method is driven with an automated or semi-automated scanner.
PA (Phased Array Ultrasound)	Phased array inspection utilizes electronically manipulated angles of ultrasonic waves that can record and store data in a digital format. This process can be automated or hand manipulated.
TOFD (Time of Flight Diffraction)	Time of Flight Diffraction is an ultrasonic method that floods the inspection material with sound for a full volumetric inspection. This method is driven with an automated or semi-automated scanner.
RT (Radiography)	Radiography is an imaging technique that uses electromagnetic radiation to view the material being inspected. This method produces a film or digitized image record.

PURPOSE

This Specification details the requirements for the radiographic examination of welds.

SCOPE / APPLICABILITY

This Specification establishes the requirements for radiographic examination of procedure qualification welds, welder performance qualification welds, and production welds. This Specification also details equipment requirements, operator and radiographic procedure qualification requirements, and quality and reporting requirements for the radiographic examination of welds.

This Specification applies to welds in natural gas and hazardous liquid pipeline applications for the Company (as well as affiliates) in United States and Mexico. Refer to TES-NDE-RT Radiographic Examination of Welds Specification (CDN) (EDMS No. 3671368) for requirements for Canada.

The Responsible Engineer shall be contacted for clarification if needed.

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1 CONTENT FRAMEWORK

The content framework in Figure 1-1 provides the general structure for the material as applicable to this Specification. This framework represents the key requirement categories outlined in Section 2.

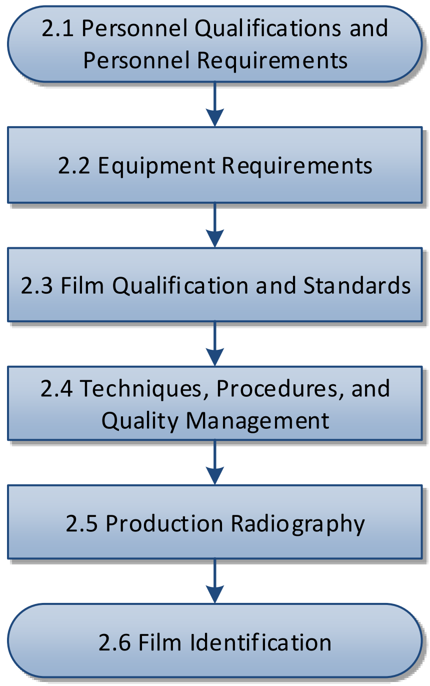

Figure 1-1: Content Framework

2 REQUIREMENTS

All radiographic examination of welds shall conform to the following requirements:

- Notwithstanding the requirements of this specification, radiographic examination shall comply with the requirements of the latest approved edition of API 1104 or ASME V, as applicable.
- All mainline girth welds, tie-in welds, replacement welds, double joint welds, and repair welds completed using manual or semi-automatic welding processes may be radiographed for 100% of the circumference in accordance with this Specification and assessed in accordance with API 1104 Section 11 or ASME V, as applicable. At the discretion of the Company these welds may alternatively be identified for ultrasonic examination.
- Only Company approved radiographic techniques shall be used.
- The Company shall have the right to non-destructively examine all welds during and after welding to ensure compliance with the standards of acceptability detailed below in this section.
- The Company shall also have the right to order removal of any weld for destructive or other examination. The Company is the final authority for the acceptance of welds.
- The general standards of acceptability for discontinuities located by all non-destructive examination (NDE) methods, including visual examination, are defined by API 1104 or ASME V, as applicable; observed defects shall be reported on Company approved Daily Radiographic Reports. Defects such as crater cracks, weld metal, heat-affected zone or base metal cracks are unacceptable, regardless of size or location.

2.1 Personnel Qualifications and Personnel Requirements

This section will outline the requirements for personnel qualifications and Contractor responsibilities.

2.1.1 Personnel Requirements

The Contractor shall provide a minimum of two personnel to perform radiography. One of the personnel shall be:

- A technical supervisor (if required by the Contract); or,
- As a minimum requirement, a Level II or Level III radiographer designated as a Technical Lead Hand who shall work closely with the Company Senior Welding Inspector and/or the NDE Inspector. The Technical Supervisor or Technical Lead Hand shall be approved by the Company.

The Contractor shall assign a Level II or Level III radiographer to each radiographic inspection unit. A Level II or Level III radiographer engaged by the Contractor shall be responsible for final film interpretation and reporting.

The Contractor may provide Level I personnel to assist in the radiographic operation under the direct supervision of a Level II or III radiographer. The Level I radiographic personnel shall not interpret radiographic film nor independently perform radiographic exposure operations or sign reports.

The Contractor shall ensure that each crew has, in their immediate possession, a complete copy of the current applicable Code(s)/Specification(s)/Standard(s).

2.2 Equipment Requirements

The radiographic units required for NDE shall be provided by the Contractor.

For pipeline projects, each of the radiographic units shall be classified as mainline, mini-mainline, tie-in, or repair. All radiographic units shall be equipped with;

- Self-contained vehicles complete with climate-controlled darkrooms for film processing and drying.
- Mainline and mini-mainline units shall be equipped with at least one self-propelled crawler (see Table 2-3, row 2), an experienced crawler operator, and other material and equipment required to expose, develop and interpret radiographs at a rate sufficient to keep up with the welding rate set by the Company or Pipeline Construction Contractor.
- Tie-in and repair units shall be equipped with X-ray tubes or Iridium 192 isotopes. The radiation type shall be defined by the Contractor in the bid and shall be subject to agreement by the Company.
- Cobalt 60 sources shall not be used with this Specification.
- Isotopes other than Iridium 192 (i.e. Selenium) shall be subject to Company approval before use.

The Contractor shall also have available on each spread, sufficient:

- Spare parts (including a complete working spare crawler when radiography of mainline girth welds is included in the scope of work), film, chemicals, and other consumables to ensure the continuance of work without interruption or delays; and
- Equipment, consumables, and qualified personnel as to provide for inspection of welds or pipe by means of liquid penetrant examination, magnetic particle examination, and ultrasonic thickness examination.

The condition and maintenance of the Contractor’s radiographic equipment shall be subject to Company examination and approval. Supplies, consumables and necessary stand-by equipment shall be on hand to ensure that construction progress shall not be delayed.

2.3 Film Qualifications and Standards

The following sections outline the qualifications and standards for film including film type, radiographic quality, procedure and technique qualifications, and test radiographs.

2.3.1 Film Type

The Company shall approve the brand and type of radiographic film proposed by the Contractor; this list of approved brands is available in Table 2-1. These films and their application do not require further Company approval, providing the required sensitivity level is met during the qualification of the technique and during production radiography. Film classification shall be in accordance with ISO 11699-1.

Alternatively, wide latitude films such as the Agfa “Structurix Wide Latitude Film” are acceptable (with prior Company approval). The use of alternate brands and types is not permitted without prior written Company approval.

Table 2-1: Acceptable Film Types

Gamma (Iridium 192)	X-Ray
Kodak* DR-50, M100, MX125	Kodak* DR-50, M100, MX125, T200
.Agfa Gevaert** D2, D3, D4	Agfa Gevaert **D2, D3, D4, D5
Fuji IX25, IX50	Fuji IX25, IX50, IX80
Notes: *Kodak manufactures film under the trademark “Kodak Industrex”. **Agfa Gevaert manufactures film under the trademark “Structurix”.	

2.3.2 Radiographic Quality

Film shall be chosen to provide good definition, contrast, latitude, and of sufficient width as to provide, where practicable, at least 1 inch of coverage on each side of the weld cap. In situations where 1 inch is not achievable, the minimum distance between the cap edge and the edge of the film shall not be less than 0.250 inch.

Films shall be exposed so that a film density throughout the area of interest shall fall within the ranges provided in Table 2-2. The area of interest shall include the full welded area and extend out 0.250 inch from either side of the cap to include the heat-affected zone (HAZ).

The base density of the unexposed film shall be checked at least once per day and shall be documented with the following information:

- date
- film brand/type
- NDE technician name
- measured Hurter and Driffield (H&D) information permanently marked on the filmstrip itself and recorded on a log or daily report to be maintained for the project

Table 2-2: Acceptable Density Ranges

Transition Welds	Unexposed density	Localized area not exceeding 50.8mm
2.0 – 4.0 H&D	≤ 0.30 H&D	1.8 – 4.2 H&D

2.3.3 Radiographic Procedure and Technique Qualification

A written procedure for the radiographic technique shall be established by the Contractor. Each radiographic technique shall be qualified by the Contractor on the first production weld available, prior to the start of production radiography. Radiographic technique qualifications shall also be performed if any of the following variables change:

- With any film change (i.e. Agfa to Kodak, Agfa D4 to Agfa D3)
- Type of radiation (X-Ray or Gamma)
- Radiographic exposure geometry (SWSI, DWSI, DWDI)
- Type of material being radiographed (i.e. carbon steel to stainless)
- Radiographer
- Project

As a minimum, the written radiographic procedure and related technique shall address all of the requirements of API 1104 or ASME V, as applicable, and include a description of the variables listed below. Changes to these variables may be subject to Company approval, provided the radiographic quality detailed in 2.3.2 of this Specification is maintained. However, the Company reserves the right to require re-qualification of a radiographic procedure or technique if any of the variables are changed or if any doubt exists regarding the ability of the procedure to produce an acceptable radiograph.

- Type of material being radiographed
- Joint bevel design
- Radiographic method e.g., single-wall or double-wall exposure
- Material thickness range for which the procedure is suitable
- Type of radiation to be used with details of effective source size or x-ray equipment voltage
- Object to film distance (OFD), Source or focal spot to film distance (SFD or FFD), Geometric Unsharpness Factor (Ug Factor), and Radiation angle with respect to the weld and film
- ASTM/ISO IQI (type of material, identification of ASTM or ISO set, essential wire, diameter/number and location)
- Position of radiation source (external or internal)
- Type, thickness, and position of intensifying screens and filters

- Sketch showing the geometric arrangement for the production of the radiographs, showing minimum source to film distance, and radiation angle with respect to the weld
- Film type and brand
- Length and width
- Number of films per weld
- Exposure conditions in milliamperes minutes or curie minutes
- The x-ray voltage or the input voltage and amperage
- Exposure time;
- Processing time and temperature for development
- Stop bath or rinse, fixing, washing and drying
- Identify whether manual or automatic
- Density (minimum and maximum)
- Sensitivity (%)
- Heat shields—material, thickness, and the distance from the film side of the heat shield to the pipe surface.

For each specific technique, the exposure conditions and radiographic quality achieved shall be recorded on a Company approved form or Company provided “Radiographic Examination Procedure Qualification Form F” (EDMS No. 8732529).

2.3.4 Test Radiograph Requirements

The radiographic quality achieved with the test radiograph must meet the requirements of this Specification. Requirements for the quality of test radiographs shall apply equally to exposures produced using both X-radiation and gamma-radiation.

The qualification test radiograph shall be reviewed and approved by the Company representative or inspector. The written procedure and test radiographs will be evaluated by the Company on the following basis:

- Film quality (e.g., fog level, handling and processing irregularities, density, sensitivity, definition, contrast and compliance with radiographic quality standards set forth in Section 2.3.2)
- Identification system
- Technique and set up
- Adequacy of the written descriptions and shooting sketches

2.4 Techniques, Procedures, and Quality Management

This section will describe the procedures, techniques, and quality management requirements for radiographic examination of girth welds.

2.4.1 Techniques

The NDE technique to be used is determined by the type of weld and the thickness of the pipe. Table 2-3 details the types of weld, pipe thickness, and the appropriate technique to be used.

Table 2-3: NDE Techniques Based on Weld Type and Pipe Thickness

Row #	Weld Description and/or Pipe Thickness	NDE Technique Description[1]
1	For pipe diameters > NPS 24 and/or thickness > 0.500inches (12.7 mm)	• X-ray tubes shall have a minimum rating of 300 kV and 3 mA. • When Iridium 192 sources are used, the curie strength for production radiography should not be less than: ▪ 30 curies for pipe diameters larger than NPS 8 but smaller than NPS 16, and ▪ 50 curies for pipe diameters NPS 16 and larger.
2	Mainline girth welds on pipe with diameters of ≥ NPS 16	• Shall be radiographed using a true radial beam X-ray crawler and single-wall exposure, single wall viewing (SWE/SWV) technique. • When a true radial beam X-ray tube is not available, permission is required from the Company to substitute a directional beam X ray tube. • Alternative radiographic techniques may be reviewed on a per contract basis to accommodate project scope.
3	Assembly girth welds on pipe with diameters of ≥ NPS 16	• Shall, wherever practicable, be radiographed using X-ray or Iridium 192 gamma radiation and SWE/SWV technique. ▪ Where this cannot be achieved, the weld may be radiographed using double wall exposure, single wall viewing (DWE/SWV) X-ray or Iridium 192 gamma radiation technique.
4	Mainline girth welds on pipe with diameters of ≥ NPS 8 but < NPS 16	• Shall be radiographed using DWE/SWV X-ray or Iridium 192 gamma radiation techniques, alternatively, a SWE/SWV technique utilizing an Iridium 192 gamma crawler may be used.
5	Assembly girth welds on pipe with diameters of ≥ NPS 8 but < NPS 16	• Shall be radiographed using the DWE/SWV X-ray or Iridium 192 gamma radiation techniques, or the SWE/SWV Iridium 192 gamma radiation technique.
6	Assembly welds on pipe with diameters of ≥ NPS 2 but < NPS 8	• Shall be radiographed using the DWE/SWV Iridium 192 gamma radiation technique. ▪ When this cannot be achieved due to quality concerns, welds NPS 3 and smaller may be radiographed using DWE/DWV Iridium 192 gamma radiation technique. ▪ Note: For ≤ NPS 4, it may be necessary to use a finer grain film to achieve the required sensitivity.

Row #	Weld Description and/or Pipe Thickness	NDE Technique Description[1]
7	Assembly welds on pipe with diameters of < NPS 2	• Shall be radiographed using the DWE/DWV Iridium 192 gamma radiation technique. • Shall be inspected using either the elliptical or superimposed DWDI techniques. • When these techniques are selected a source side image quality indicator (IQI) must be used. • The IQI selection shall be based on two times the nominal pipe wall thickness for the elliptical technique, and two times the weld thickness for the superimposed technique. • For the elliptical technique two exposures 90 degrees apart shall be made and for the superimposed technique three exposures 60 or 120 degrees apart shall be made. • Where practical, the source to object distance for DWDI radiographs shall be a minimum of ten (10) pipe diameters distance.
8	Pipeline tie-in welds, replacement welds, repair welds, completed using manual or semi-automatic welding processes	• May be radiographed using X-ray or Iridium 192 gamma radiation. The radiation source should be selected with consideration to the material thickness and latitude required to radiograph welds between materials of different thicknesses.
9	Self -Shielded Arc Weld (FCAW)	• Requires a specific Company approved radiographic procedure with consideration to the detection of Barium slag and its sensitivity to the energies of radiation used. • Radiation energy shall be 50 curies or greater for gamma isotopes, or X-ray machine having a rated capacity of 300Kv or greater.

10	Transition Welds	• For transition welds between pipes of different wall thicknesses where the density requirements of Section 2.3.2 cannot be achieved using a selected single film from Table 2-1:
		  ▪ Separate radiographs may be produced to achieve the density requirements of section 2.3.2 for each wall thickness; or
		  ▪ Cassettes should be double loaded using two suitable complementing speed films selected from Table 2-1 to achieve the required density range across the transition.

Notes:

[1] A single-wall exposure, single wall view radiographic technique shall be used whenever practical. A double-wall, single image, technique shall have a minimum of three exposures for each weld.

2.4.2 Alternative Radiographic Technologies

The use of real time radiographic (RTR) imaging techniques or a digital image acquisition medium require pre-qualification by the Company. All relevant quality requirements detailed in the specification and applicable construction code will apply to these systems and imaging mediums. These Company pre-qualifications will be contractor specific and not global pre-qualifications based on equipment manufacturer.

2.4.3 Procedures

Radiographic examination shall be performed by the Contractor in accordance with a documented, detailed procedure provided by the Contractor and approved by the Company.

2.4.4 Quality Management

Prior to the start of the project, the Contractor shall submit to the Company, a project-specific Implementation Plan together with a Quality Management Plan, upon request.

2.4.4.1 Audits

All NDE operations are subject to audit by the Company. NDE audits shall be planned and conducted by a Company auditor with appropriate qualifications in non-destructive examination, on a periodic but random basis, to verify compliance with Specification and Contract requirements. The Company auditor shall have the right to examine all procedures, reports, radiographs, and equipment both during and after production of radiographs, complete an audit report, recommend disposition of any nonconformance, and suggest appropriate corrective actions when required. If the Company audit finds a required corrective action, these findings shall be addressed in a timely manner.

The audit process is detailed in TEP-NDT-ADT Procedure for Nondestructive Examination (NDE) (EDMS No. 3797402).

Production Radiography

The following sections outline key requirements for radiographic examination of welds including visual examination, image requirement, information only exposure, interpretation, sensitivity, blemishes, inspections and repairs.

The radiographic procedure, technique, and test radiograph shall be on-site and available for review.

2.4.5 General

When the radiographic source is outside and more than 0.5 inches (12.7 mm) from the weld surface, at least four exposures separated by 90 degrees shall be made for the radiographic inspection of a complete weld.

Whenever more than one film is used to inspect a weld:

- Complete weld identification shall appear on each film segment;
- Adjacent films shall overlap by a minimum of 2 inches (50.8 mm);

- At the ends of adjacent films, the same circumferential location marker shall appear on both films, as evidence of complete coverage; and
- When more than one film cassette is used for a single exposure, the sealed end of the first cassette shall be in contact with the pipe surface and the flap end of the next cassette shall overlap the first. Subsequent cassettes shall follow the same configuration.

The radiation angle with respect to the weld and film shall be as near to perpendicular as possible with a maximum deviation of five degrees except when superimposed, double wall exposure, double wall viewing procedure is used.

2.4.6 Visual Inspection

Prior to radiographic examination, the Contractor shall visually examine each weld to ensure welds or piping with conditions such as arc strikes, or imperfections which exceed the requirements of Section 2 are repaired prior to performing radiographic examination.

2.4.7 Radiographic Image requirements

The Contractor shall ensure that the materials used to provide the radiographic images on the film meet the requirements of the Company, ASTM 1999, and API 1104. Details regarding the intensifying screen and film density requirements are outlined in Table 2-4.

Table 2-4: Intensifying Screen, Film Density, and Film Development Requirements

Item	Details
Intensifying Screens	• Shall be made from lead. • Front and back screens shall have a minimum thickness of 0.005 inches (0.13 mm). • When performing gamma radiography, the recommended thickness for back screens is 0.010 inches (0.26 mm) to account for backscattered radiation. • The back screen thickness shall be equal to, or greater than the front screen thickness. • A center screen shall be used when double loading cassettes. • The recommended thickness for center screens, when required for a multi film technique, is 0.010 inches (0.26 mm). • Damaged screens shall be discarded. • Fluorescent and Fluorometallic intensifying screens shall not be used. • Prepackaged Radiographic film sandwiched between lead screens in a vacuum sealed, flexible cassette may be used with intensification screens thinner than specified above provided all quality requirements of this Specification and API 1104/ASME V, as applicable, are met.

Item	Details
Density Measure	• To ensure that film densities are within specified limits, a calibrated densitometer shall be provided for each construction spread and a certified density strip traceable to a national standard shall be provided for each darkroom provided by the Contractor. • The densitometer shall have a valid calibration certificate. • The film strip should have density steps ranging from 0.30 to 4.0 H&D. • The use of a film strip alone to estimate radiograph or defect density is prohibited. • Farmer's Reagent or similar solutions for density reductions shall not be permitted.
Film Processing	• Sight development techniques are prohibited. • Time and temperature for development, stopping, rinsing, and fixing film shall be in accordance with ASTM 1999. • Film shall be fully fixed. • Time in the fixer shall be at least twice the clearing time, but not less than three minutes. • Wash time for manual processing shall be at least twenty minutes, whenever practical. • Wash water shall be changed as needed, but at least once per day. • The Contractor shall provide thermometers and timers for all inspection units. • Dates of solution changes shall be posted in the darkroom at all times and documented in a project log. • All chemicals required for film processing shall be prepared and properly discarded in accordance with the manufacturer's directions. • Disposal shall be in accordance with environmental regulations. • All darkrooms used for film processing shall be equipped with forced air film dryers. • Final interpretation of all film shall be performed on properly dried film.

2.4.8 Information Only Exposures

The execution of “Information Only” exposures shall adhere to the requirements in this Specification and shall meet all Company and API 1104/ASME V, as applicable, quality requirements. Radiographs that do not meet all Company and API 1104/ASME V, as applicable, quality requirements shall not be subject to interpretation.

2.4.9 Interpretation

For final film interpretation, the Contractor shall provide a variable luminosity, high intensity viewer with a screen size of sufficient capacity to allow adequate viewing of film having a density up to H&D 4.0. The Contractor shall provide another identical high intensity, variable luminosity viewer and calibrated densitometer for use by the Company in the field office.

2.4.10 Radiographic Sensitivity

Radiographic sensitivity shall be measured using an image quality indicator (IQI). Wire type IQI's shall be used, conforming to ASTM E747 or ISO 19232-1. Hole type IQI's are prohibited. See Table 2-5 for required IQI essential wire image visibility per API 1104.

Unless notified in writing by the Company, API 1104 shall be the code of construction. The thickness of the weld shall mean nominal pipe wall thickness plus the average weld reinforcement (internal plus external combined). The value of the total thickness of reinforcement applied during IQI selection shall not exceed the lesser of 0.125 inches or the maximum allowed by the code of construction. The number of IQI's, and their placement, shall be per the code of construction. Film side IQI 's shall be identified using a lead letter "F".

The radiographic images of IQI identifying style number and ASTM set letter or ISO designation shall appear clearly across the entire area of interest. The IQI shall be placed across the weld and the long axis of the wires shall be perpendicular to the weld axis. The image of the essential wire diameter shall appear clearly across the entire area of interest. All wires shall completely cross the weld. Damaged wire sets shall be discarded. In cases where weld cap width exceeds the IQI length, IQI's shall be placed from both perpendicular directions.

For transition welds between two wall thicknesses, the thinner wall shall be used to determine the required sensitivity.

Table 2-5: API 1104 Weld Thickness Versus Diameter of Wire Type IQI

Weld Thickness	Essential wire	ASTM E 747 Set	ISO 1027 Wire Identity
Less than 0.250" (6.4 mm)	0.008" (0.20 mm)	A	13
0.250"through 0.375" (6.4 to 9.6 mm)	0.010" (0.25 mm)	A or B	12
Greater than 0.375" through 0.500" (9.6 to 12.7 mm)	0.013" (0.33 mm)	B	11
Greater than 0.500" through 0.750" (12.7 to 19 mm)	0.016" (0.41 mm)	B	10
Greater than 0.750" through 1.0" (19 to 25.4 mm)	0.020" (0.51 mm)	B	9
Greater than 1.0" through 2.0" (25.4 mm to 50.8 mm)	0.025" (0.64 mm)	B	8

2.4.11 Blemishes

Radiographs presented for interpretation shall be free from blemishes or film defects that might mask or be confused with imperfections in the material. To ensure adequate control of back scatter, a lead letter "B" shall be attached to the back surface of the film cassette. If a light image of the "B," appears on a darker background of the radiograph, protection from backscatter is insufficient and the radiograph shall be considered unacceptable. A dark image of the "B" on a lighter background is not cause for rejection.

Typical blemishes include, but are not limited to one or more of the following:

- Fogging caused by light leaks or defective safelights
- Exposure marks caused by improper processing or old film
- Mechanical processing defects such as streaking, air bubbles watermarks, or chemical stains

- Blemishes caused by dirt in film holder
- Pressure or lead marks, scratches, gouges, finger marks, crimp marks or static electricity damage
- Loss of detail caused by poor film to screen contact in localized areas

Geometric unsharpness shall be kept to a minimum and shall not exceed 0.020 inches (0.5 mm) for weld thicknesses less than 2 inches (50.8 mm).

2.4.12 Delayed Inspection

When a delayed inspection is mandated by the Company, the weld shall be radiographed for initial acceptance for code compliance. The second (i.e. delay) inspection for final acceptance shall occur after the required delay time.

Defects found during the initial inspection shall be repaired. The delay time for final acceptance, if required, will commence once the repair has been completed.

The time of radiography will be marked on the pipe near the marked weld time. The time of radiographic examination shall be identified in the radiographic report.

2.4.13 Repair Welds

When a repaired weld is radiographed, an additional IQI shall be placed across to each repaired area.

2.5 Film Identification

The Contractor shall clearly identify each radiographic film with a unique weld identification number designated by the Company, along with any other information specified by the Company, in a manner approved by the Company (e.g., lead numbers and letters, or flash cards (EDMS No. 8737175). Table 2-6 details the required information.

Table 2-6: Film Identification Requirements

Item	Details
Location Markers	• Location markers shall be provided so that discontinuities in the weld can be quickly and accurately located. • The location markers shall be placed on the pipe on the downstream side of the weld, so that the numbers shall be read clockwise when viewed on the upstream side. • Identification and location markers shall be readily visible on radiographs and shall not encroach on the weld image or other area of interest. • Identifying numbers or letters shall be at least 3/32 inches (2.4 mm) high.
Marker Separation	• The maximum separation for weld location markers shall be 2 inches (50 mm) for NPS 16 and smaller welds, and 6 inches (150 mm) for welds larger than NPS 16.
Zero Location	• The zero location number shall correspond to the 12 o'clock position on the pipe whenever practicable.

3 VARIANCES

Any deviation must follow the appropriate TransCanada Management of Change (MOC) Variance Procedure (EDMS No. 7728702).

4 ROLES AND RESPONSIBILITIES

Table 4-1 outlines the roles and responsibilities required for the use of this Specification.

Table 4-1: Roles and Responsibilities

Role	Responsibilities
Radiographer	The radiographer shall be responsible for the protection and monitoring of every person working with or near radiation sources. The protection and monitoring shall comply with applicable federal, state, and local regulations.
Welding Inspector	The Welding Inspector is responsible for monitoring / confirming that: • All welds are examined in accordance with this specification
Contractor	The Contractor is responsible for ensuring: • All required welds are examined in accordance with this specification
Level I Radiographer	The Level I Radiographer is responsible for providing assistance where necessary to the Level II and Level III Radiographer(s)
Level II or III Radiographer	The Level II or III Radiographer is responsible for ensuring: • That the final film is interpreted and reported • Proper conduct and performance of all NDE Personnel • Compliance with acceptance criteria
Technical Lead or Supervisor	The Technical Lead or Supervisor is responsible for ensuring: • That the final film is interpreted and reported • Proper conduct and performance of all non-destructive examination and personnel • Compliance with acceptance criteria and specification including documented proof of review • Maintenance of all Contractor facilities, equipment, and supplies in a reliable condition • Preparation of accurate, consistent, legible and concise reports in a timely manner

5 TRAINING AND QUALIFICATIONS

If required by the Company, the Contractor shall provide training (one-day minimum) for Company Inspectors on the Contractor techniques and management system for radiographic inspection. This training shall be at a date and location designated by the Company and shall occur prior to the start of production welding.

To ensure the consistent production of high quality radiographs, radiographic personnel shall be qualified in accordance with this section. A minimum qualification for personnel referred to herein as Level II radiographers shall be:

- Certified by examination in the radiographic test method in accordance with ASNT SNT-TC-1A, CP 189 or ACCP recommended practice;
- Qualified by production of at least one test radiograph for each Company approved radiographic technique used on the work (see Section 2.3.2) which shall be retained and evaluated by the Company on the basis of overall film quality and adherence to these specifications; and
- Approved by the Company for the work prior to production where practicable.

Personnel shall provide the following documentation:

- Background and experience record
- Company or ASNT/ACCP certification records
- Training course record
- Date of qualification and re-qualification
- Jaeger J-2 Acuity eye tests and results
- Operator Qualification (OQ) results for the radiographic method (conditionally required)

All Level II and III supervisory personnel should be qualified as a minimum to ANSI/ASNT-CP-189.

The Company shall have the right to evaluate the qualifications of all NDE personnel and to exclude individuals that, in the opinion of the Company, lack necessary training or experience for the work or have demonstrated an inability to adequately perform the prescribed examinations. Incompetence or lack of diligence at any time may result in immediate termination from the project.

6 SAFETY CONSIDERATIONS

The Contractor and all personnel operating X-ray or gamma-ray equipment shall be responsible for the protection and monitoring of every person working with or near radiation, and for compliance with the regulations of the Department of Health and Welfare Canada, Health Protection Branch concerning radiation safety, transportation, and certification.

The Contractor shall have a written radiation safety plan satisfying United States Nuclear Regulatory Commission (USNRC) requirements and applicable federal, state, and local laws, available on the work site at all times. This radiation safety plan shall be available for review upon request.

Personnel conducting radiographic operations shall properly utilize the following:

- Personal Thermo Luminescent Dosimeter (TLD) or film badge

- Survey meter with valid calibration
- Accumulative dose monitors (dosimeters) with valid calibration
- Rate alarm meter with valid calibration
- Appropriate type and number of radiation warning cones, barriers, signs and/or tape

7 ENVIRONMENTAL CONSIDERATIONS

No incremental Environmental Considerations are identified for this Specification.

8 GLOSSARY

Definitions related to this Specification can be found in Appendix A.

9 REFERENCES

This document relies on a number of references to legislation (act, statutes, and regulations), certificates, and orders and may include directives, guidelines, standards, and codes to the extent they contain legally binding requirements for TransCanada.

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 9-1.

Table 9-1: External and Internal References

Document No.	Title
Legal Requirements	
DOT 49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards and any amendment, supplement or errata issued by the DOT.
DOT 49 CFR 195	Transportation of Hazardous Liquids by Pipeline and any amendment, supplement, or errata issued by the DOT.
United States Nuclear Regulatory Commission (USNRC)	Federal Radiation Safety Regulations. State and local jurisdiction regulations also apply.
Industry Codes and Standards	
API 1104	Welding of Pipelines and Related Facilities.
ASNT-CP-189	American Society of Non-Destructive Testing (ASNT) Standard for Qualification and Certification of Nondestructive Testing Personnel.
ASNT-TC-1A	ASNT Recommended Practice for Qualification and Certification of Nondestructive Testing Personnel.
ASTM E94	Standard Guide for Radiographic Examination.
ASTM E747	Standard Practice for Design, Manufacture, and Material Grouping Classification

Document No.	Title
	of Wire Image Quality Indicators (IQI) Used for Radiology.
ASTM E999	Standard Guide for Controlling the Quality of Industrial Radiographic Film Processing.
ASTM E1316	Standard Guide for Terminology for Non Destructive Examinations
ASTM E1815	Standard Test Method for Classification of Film Systems for Industrial Radiography.
ISO 19232-1	Non-destructive testing - Image Quality of Radiographs - Part 1: Image Quality Indicators (Wire Type) - Determination of Image Quality Value
Internal References – Documents that Reference this Specification	
EDMS No. 1001828336	TEN-NDT NDT Standard (CDN-US-mex)
EDMS No. 1001828218	TES-WELD-API Welding of Pipelines and Facilities Specification (US-MEX)
Internal References – Documents Referenced by this Specification	
EDMS No. 3797402	TEP-NDT-ADT Procedure for NDE Audits Specification (US-MEX)
EDMS No. 1001828218	TES-WELD-API Welding of Pipelines and Facilities Specification (US-MEX)

10 DOCUMENTATION AND RECORDKEEPING

Due to the broad range of data types that may be required in support of this Specification, there are a number of processes that may need to be utilized for documentation purposes. These data types include but are not limited to:

- storage of developed radiographic images/film
- daily radiographic reports
- project log
- Radiographic Examination Procedure Qualification Form "F" (EDMS No. 8732529)
- radiation safety plan
- weld repair list

10.1 Storage of Developed Radiographic Images/Film

All radiographic films and associated documentation shall become the property of the Company. Unless authorized by the Company in writing, duplicate production radiographs shall not be executed. Electronic transfer of production radiographs is subject to written Company approval.

10.1.1 Processing for Storage

All radiographic films shall be processed by the Contractor prior to being stored in a location determined by the Company. Table 10-1 details the requirements of this processing.

Table 10-1: Processing Film for Storage

Item	Details
Wash Film	• The Contractor shall ensure that all film is thoroughly washed and dried before packaging and that all film is packaged in sequential order with a copy of the Daily Radiographic Report.
Catalogue Film	• Completed radiographs shall be either catalogued and packaged in cardboard boxes supplied by the Contractor, or for fabrication welds or oversize films, in suitable sized envelopes. • The contents shall be clearly identified on each envelope. These envelopes will then be stored in suitable sized boxes and identified using a label for archiving. • For cubicle boxes, radiographs shall be inserted into each cubicle in sequence stating from the left side of the first row toward the right and then from the right side of the second row toward the left and so on. The bottom of each cubicle shall be clearly marked with the film number, i.e. weld number that shall occupy that space, after the radiograph has been interpreted.
Processing of Radiographs of Repaired Welds	• Radiographs of repaired welds shall be rolled or inserted with the original radiograph such that both films are stored in the same cubicle or when envelopes are used they shall be included in the same envelope/box.
Processing of Radiographs of Replaced Cut-out	• Radiographs of replaced cut-out welds shall be placed in the same cubicle or envelope as the original film. If there is not enough room, then the original film may be removed and filed in a box/envelope identified as a cut-out box.
Removal of Staples	• All staples used to hold film(s) together shall be removed prior to storing.
Interpretation Sheets	• Clear and legible interpretation sheets shall be included inside the boxes for those films catalogued in the corresponding boxes. Each time a new box is started, a new interpretation sheet shall be started. These sheets shall then be inserted inside the corresponding box or envelope.
Labeling	• The Contractor shall supply labels for the radiographic boxes. The boxes and labels shall be numbered sequentially starting from number one. As films are being processed, the Contractor shall complete the labels with the information specified below and place the labels in the same location on the side of each completed radiographic box. ▪ Project name, location, or spread number ▪ Range of weld numbers ▪ Range of chainage, for pipeline projects when requested by the Company ▪ Range of dates exposed ▪ Box number ▪ Contractor's name ▪ Other specific information required by the Project/Construction Manager

Item	Details
Storage	• Radiographic film and associated reports shall be forwarded to the Company for storage. Film processing shall be adequate to permit storage without deterioration for a minimum period of seven years.

10.2 Project Log

The Contractor or Fabricator shall keep a logbook approved by the Company for repairs of all welds throughout the project. At the completion of the project, the Contractor shall provide a copy of the approved logbook to the Company.

10.3 Daily Radiographic Reports

At the end of each day, the Contractor shall supply to the Company details of all radiographic inspection completed that day on the Daily Radiographic Reports.

Radiographic inspection reports shall include but are not limited to the following information:

- Date of inspection (i.e. Month/Day/Year)
- Film type used
- Technique used
- Source strength (curies or Ma/Kv)
- Pipe diameter and wall thickness
- IQI identification
- Company, project name and number
- Code of construction as per construction requirements
- Company Specification and acceptance criteria used
- Spool number (if applicable)
- Weld number
- Disposition
- Technician name and certification
- Company representative approval
- Density measure taken of daily unexposed base film

10.3.1 Weld Repair List

Weld repair lists shall be provided to the Company in electronic and hard copy format each working day at a cut off time specified by the Company and agreed to by the Contractor.

Repair lists shall report weld quality, including outstanding weld repairs and/or cutouts, for all welds completed prior to the production cut off time on that day.

The Contractor shall have sufficient equipment and personnel on site to maintain a production rate, which ensures any weld completed prior to the production cut off time on any working day shall be inspected, interpreted, and included in the Daily Radiographic Report for that working day.

11 DOCUMENT HISTORY

Rev.		
05	**Description**	**Effective Date**
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	**Responsible Engineer**
	This document was revised in order to address the following requirements: Alignment with new document definitions, structure, and templates.	Simon Hsu, Sr. Welding Engineer
	Impact Assessment Summary	**Document Owner**
	This specification was revised to streamline the documentation required for the NDE group and to make it more easily accessible to those who use it.	Simon Hsu, Sr. Welding Engineer

12 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A.
Industry Standards	
N/A	N/A.
General	
N/A	This Specification is a new document.

13 APPROVALS

APPROVALS	
Originator: Salvatore Delisi, Senior Welding Technologist Welding and Materials Engineering	Salvatore J. Delisi 10/25/16 Signature Date
Reviewer: Jason Althouse, Senior NDE Technologist Welding and Materials Engineering	10/25/16 Signature Date
Responsible Engineer: Simon Hsu Sr. Welding Engineer Welding and Materials Engineering	Simon Hsu Signature 10/25/2016 Date
Management Endorsement: James Ferguson, Manager Welding and Materials Engineering	Nov. 1, 2016 Signature Date

APPENDIX A TERMS AND DEFINITIONS

Terms	Definitions
Assembly Weld	Weld joining pipe to components, or components to components; weld joining pipe to pipe made in stations or at a manufacturing plant or fabrication shop remote from the final location of the weld
Company	TransCanada including their engineering agencies, inspectors and other authorized representatives.
Component	Valves, fittings
Contractor	The Contractor engaged by the Pipeline Construction Contractor to perform the radiographic inspection work covered by this Specification.
DWDI	Double-wall, double-image
DWSI	Double wall, single image
IQI	Image quality indicator
Mainline Weld	Pipe-to-pipe weld made on a pipeline site
Radiographic Personnel	Operators of radiographic equipment. Radiographers referred to herein shall be certified to Level II or III in accordance with a written practice based on the latest edition of ASNT SNT-TC-1A or ANSI/ASNT-CP-189. Level I personnel (trainees) are not considered to be radiographers.
Pipeline	A pipeline for the transmission of natural gas or hazardous liquids including laterals, branch connections, extensions, compressors, pumps, and related facilities as defined by 49 CFR 195 Transportation of Hazardous Liquids by Pipeline or by 49 CFR 192 Transportation of Natural and Other Gas by Pipeline, Minimum Federal Safety Standards.
Nondestructive (NDE) Audit	An official examination of the Contractor's procedures, reports, radiographs, equipment and systems used for nondestructive examinations.
SWSI	Single-wall, single-image

PURPOSE

This Specification is issued to provide the Company requirements for ultrasonic examination of girth welds.

SCOPE / APPLICABILITY

This Specification details the requirements for the examination of pipeline girth welds using a mechanized and manual (APPENDIX C) ultrasonic examination system. The requirements outlined include: contractor requirements; equipment; calibration standards, procedures, techniques, and quality management; system set-up; examination; indicator evaluation; and records and reports.

This Specification applies to new welds made in pipe with a nominal wall thickness of:

- 0.250 in. (6.4 mm) and greater with a factory weld bevel
- 0.283 in. (7.2 mm) and greater with a gas metal arc weld bevel

This Specification applies to the Company and its wholly-owned subsidiaries, and all operated entities/facilities in the United States (U.S.) and Mexico.

The Responsible Engineer shall be contacted for clarification if needed.

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1 CONTENT FRAMEWORK

The content framework in Figure 1-1 provides the general structure for the material as applicable to this Specification. This framework represents the requirement categories outlined in Section 2.

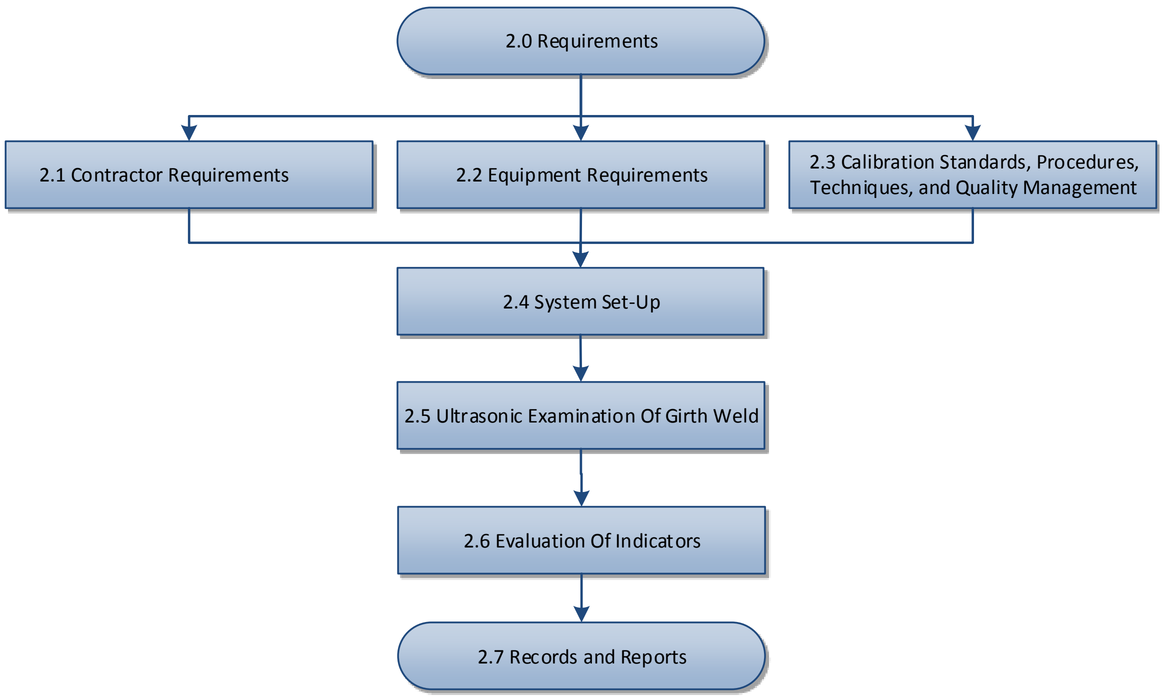


Figure 1-1: Content Framework

2 REQUIREMENTS

All ultrasonic examination of girth welds shall conform to the following requirements:

- Notwithstanding the requirements set forth herein, ultrasonic examination shall comply with the requirements of the latest approved edition of API 1104, as incorporated by reference by 49CFR 192.7, or 49CFR Part 195.3, as appropriate.
- While most project work will be performed to API 1104 standards, in some cases, ultrasonic procedures may be developed in accordance with ASME V, and evaluated to ASME Section VIII, Division I, Mandatory Appendix 12. While this Specification defaults to API 1104, the NDE Contractor will be so advised when ASME criteria is relevant. For purposes of this Specification, references to API 1104 also include ASME criteria, if relevant.
- Mechanized girth welds, girth welds made in a factory bevel, and repairs made to welds produced using mechanized welding shall be fully examined by an automated ultrasonic examination system for 100% of the circumference, in accordance with API 1104, Appendix A.
- Girth welds made in a factory bevel which cannot be inspected by automated ultrasonic examination may, where practicable and with permission of the Company, be inspected by manual ultrasonic examination according to APPENDIX C of this Specification.
- The examination system shall be capable of assessing circumferential length of defects and predicting the through-wall height and circumferential length of defects, in a manner that permits the use of acceptance criteria defined by the Company in accordance with API 1104, Section 9.6.2 “Acceptance Standards”.
- Each examination system shall incorporate a time of flight diffraction (TOFD) configuration; this shall augment, but not replace, the pulse-echo system.
- The Pipeline Contractor should be aware of these requirements and work with the NDE Contractor to ensure that welds are prepared and available for examination as required by the Company.
- The Company shall have the right to non-destructively examine any weld; the examination shall be used to assess compliance with CFR 192, 49 CFR 195, and API 1104. The Company shall also have the right to require the removal of any weld for the purpose of destructive tests.
- The Company is the final authority for the acceptance of welds.
- For each project, the Contractor shall demonstrate the accuracy of the system for assessing through-wall height imperfections according to API 1104 Appendix A in welds produced in project pipe. The accuracy should be verified by destructive testing results unless an alternate approach is applied, in accordance with API 1104 Appendix A. This accuracy shall be demonstrated on the thinnest and the thickest wall thickness of project pipe. The Company shall be sole judge of the adequacy of system performance for the intended use.

2.1 Contractor Requirements

The Contractor shall provide ultrasonic examination services for all automatic girth and any other welds designated by the Company during the construction of a pipeline or facility, as described in Section 2.5 of this Specification.

Before system mobilization, all the performance tests and documents listed in Section 10 shall be completed by the Contractor and approved by the Company.

The Contractor shall have sufficient equipment and personnel on site to maintain a production rate which ensures that any weld completed prior to the daily cut off time specified by the Company shall be inspected, interpreted and included in the Ultrasonic Examination Report for that working day, unless otherwise directed by the Company.

Table 2-1 outlines other key requirements of the Contractor.

Table 2-1: Contractor Requirements

Topic	Description
Designs	• Project specific examination designs shall be developed by the Contractor following the requirements of APPENDIX A of this Specification for mechanized welding bevel configurations, and APPENDIX B for welds produced in a standard factory bevel. • Using either the design information provided by the Company or derived from the relevant Appendix, the Contractor shall prepare a detailed technique for each wall thickness to be inspected by automated ultrasonic examination. • The Contractor shall only prepare a detailed technique(s) for manual ultrasonic examination when required by the Company.
Equipment	• The Contractor shall have necessary spare equipment to ensure continuance of the work without interruption or delays. • The Contractor shall supply a viewer program to enable the Company to view the raw data in the same manner used by the system operator at the time of examination. • The program shall allow the Company to verify amplitude or TOFD indication height values from the raw data, in addition to viewing the specific scan parameters used, including focal law information for phased array systems.
Personnel	• The Contractor shall designate one person as the NDE Supervisor. This person shall be responsible for the conduct and performance of all ultrasonic personnel and for maintaining all equipment and supplies in reliable condition. • The NDE Supervisor shall be a certified Level II or Level III (ASNT TC-1A, ACCP, CP-189) in the ultrasonic method and work closely with the Company's Senior Welding Inspector in the documentation of examinations completed and shall be responsible for all reports, interpretations, and evaluation. • The NDE Supervisor shall audit daily the electronic data to ensure that interpretations are consistent, informative, and concise, and the NDE Supervisor shall be capable of technical support for NDE operations. The extent of data audit shall be approved by the Company. • The NDE Supervisor shall be approved by the Company based upon experience, technical knowledge, and NDE qualifications for the duties to be performed.

Topic	Description
Records	• The Contractor shall provide the Company with an electronic copy of the raw data and a hard copy or PDF recording of the examination, together with the judgment of acceptability of each weld examined and the recordings of the calibration standard scans. • The raw data shall capture the A-scan signal within the gated period of each sequence at a sampling rate allowing proper reconstruction of the signal.

2.2 Equipment Requirements

The ultrasonic examination shall be carried out using an automatic ultrasonic system capable of maintaining production rates established by the Pipeline Construction Contractor. At times, this can be as many as 150 welds/day. The system shall be self-contained, have its own independent power supply, and be mounted on a suitable all-terrain vehicle.

A stacked A-scan mapping display shall be provided for each root and volumetric sequence/channel in addition to an analog strip recording for all sequences/channels. A selectable A-scan presentation shall be available during scanning.

When required, there shall be an A-scan presentation of the gated period available for viewing in the display for any selected analog strip sequence/channel during scanning. The instrument shall provide a linear A-scan presentation for each channel selected. The examination channels shall allow assessment of the full volume of the weld scanned, and all defects present detected, located, and sized in the circumferential and through-wall direction. Instrument linearity shall be determined according to ASTM E317, within 3 months of the intended end use date, and not deviate by more than 5% from ideal. The Contractor shall retain a current copy of the calibration certificate at the worksite.

Each examination channel shall provide:

- Pulse echo or through transmission modes
- Two gates, each adjustable for start position and length
- Gain adjustment independent of the other examination channels
- Recording threshold between 5% and 100% of full screen height (FSH) for A-scan and transit time recording and 0% to 100% for stacked A-scan mapping
- For TOFD waveforms, a recording threshold of 100% to -100%
- Recording of the first or the largest signal in the gated region
- Signal outputs representing signal amplitude and time of flight

Table 2-2 outlines additional requirements for Phased Array, Time of Flight Diffraction, and Transducers.

Table 2-2: Additional Equipment Requirements

Equipment	Description of Requirement
Phased Array (PA)	Phased array technology may be used as an alternative to a focused multi-probe array. In that circumstance, the Contractor shall apply the following additional requirements: • Phased array systems will simulate the focused multi-probe array system function for weld volume examination. Sectorial scans are permissible when required to provide enhanced defect height sizing. • Phased array equipment shall meet the requirements of Part 1, 2, and 3 of BS EN 12668. • Phased array transducers shall have a minimum of 48 elements. Due to the large wedge footprint (and therefore sensitivity to surface waviness), care must be taken to ensure the contact surface is properly dressed to match the contour of the pipe surface. The permissible gap between pipe and wedge shall not exceed 0.010 in. (0.25 mm). • Phased array transducers shall contain shaped elements or suitable lens in the passive non-steered direction, radius three (3) to five (5) inches (75 to 125 mm). Alternatively, phased array transducers that result in a beamspread limitation of 4 mm in the passive non-steered direction may be permissible. • Each array will be assessed at intervals not exceeding 800 welds or 1 week of production, whichever comes first, to confirm continued element integrity and performance within the Manufacturer's acceptable tolerance. The Contractor shall follow the Manufacturer's performance tolerances with respect to sensitivity across the array and the number of non-active elements. • Each focal law will provide for the maximum sound pressure at the target defined in the examination design. The focus shall occur at the target ±10 mm of steel path and the beam height shall be within ± 20% of that required by the examination design. • Software locks should be active for each focal law to limit changes by the system operator which will alter the initial system configuration approved by the Company Representative. Changes shall only be permitted by the Contractor Job Supervisor with approval of the Company Representative. The Contractor shall demonstrate the tolerance to ideal for each focal law. • With permission from the Company, a software feature which identifies that a focal law is outside the tolerance set for that focal law may be substituted for software locks. This out of range condition shall appear in the display continuously until corrected and recorded in the raw data for welds examined with this out of range condition.
Time of Flight Diffraction (TOFD)	• A single TOFD configuration shall be used for wall thickness ≤ 1 in. (25 mm), whereas a dual TOFD configuration shall be used for wall thickness > 1 in. (25 mm). • TOFD shall be configured following BS EN 583-6:2008 guidelines. • The receiver bandwidth shall have a range of 0.5 to 2 times the nominal transducer frequency at -6dB. • The system shall have an electronic gate with both start and length within the unrectified A scan which is digitized. • Lateral Wave (LW) shall be a minimum of 12 dB greater than baseline noise. • The gate should be set starting 1 microsecond prior to the arrival of the lateral wave and extend to ensure that both the complete reflected back wall signal and the mode converted signal is recorded.

<table>
<tr><th>Equipment</th><th>Description of Requirement</th></tr>
<tr><td></td><td>
The digitization rate shall be at least 4 times the nominal transducer frequency.
The system shall be able to acquire, digitize, and display at least one A-scan for each 1mm of scan length.
The system shall be capable of displaying D-Scan images in at least 256 grey scale levels.
If pre amplifiers are used, then the bandwidth of the pre amplifier at -3dB shall be similar to that of the system.
The preamplifier shall be low noise, better than 20μV peak to peak.
</td></tr>
<tr><td>Transducers</td><td>
All transducers shall utilize contoured wedges to match the curvature of the pipe surface.
Transducers shall not operate on or transmit/receive ultrasonic energy through the coating.
The acoustic focus shall occur at the target ±10 mm of steel path and the beam height shall be within ±25% of that required by the examination design. The -6 dB horizontal dimension of the beam at the target shall not be greater than two times the -6 dB vertical dimension of the beam.
Transducers other than phased array shall be certified as meeting the performance requirements of British Electrical Supply Industry Standard ESI 98-2.
Each transducer's performance shall be documented before use on a Contractor developed form approved by the Company.
Whenever wear is apparent, but not greater than an interval of 500 welds, transducers shall be examined for wear as per Section 2.4.3 of this Specification.
The signal-to-noise value for each transducer shall be compared to the value obtained in accordance with Section 2.4.2 of this Specification at the start of the project.
Case heights and the signal-to-noise value for each transducer shall be recorded on Company-approved forms.
For conventional (non-phased array) transducers, the contact face shall be re-surfaced, or the transducers replaced to correct any of the following:
Beam angle changes of ±1.5 degrees for angles less than 45 degrees, or ±2 degrees for angles greater than 45 degrees
Squint angles exceeding 1.5 degrees for single crystal transducers and 2 degrees for twin crystal transducers
A signal-to-noise value 6 dB less than the value obtained at the start of the project
Scores in the transducer wear face which exceed 0.2 mm in depth

Phased array transducers shall be replaced or resurfaced if the naturally refracted angle deviates more than ±1.5° of approved technique angle.
Phased array transducers shall be re-surfaced if scores on the contact face exceed 0.2 mm in depth
</td></tr>
</table>

2.3 Calibration Standards, Procedures, Techniques, and Quality Management

This section describes the equipment calibration standards, procedures, techniques, and quality management requirements for automated ultrasonic examination of girth welds.

2.3.1 Calibration Standards

Calibration standards shall be used to qualify the system for field examination and to monitor ongoing system performance.

The following calibration standard requirements apply to automated ultrasonic examination of girth welds:

- Calibration standards shall be manufactured from a section of project specific line pipe supplied by the Company and designed such that the target reflectors simulate the bevel geometry to be inspected.
- Calibration standards shall be identified with a unique serial number providing traceability back to the project for which they were manufactured. Records of the serial number, wall thickness, diameter, and acoustic velocity shall be kept. Calibration standards remain the property of the Company.
- Calibration standards shall be designed with sufficient surface area so that the complete transducer array will traverse the target areas in a single pass. The lateral position of calibration reflectors shall be such that there will be no interference from adjacent reflectors, or the edges of the block.
- The number of calibration reflectors shall be adequate to provide better than ±1.5 mm of height sizing accuracy, clearly discriminate buried from surface breaking imperfections, as well as enable classification of imperfection type, planar, and volumetric as per API 1104, Appendix A.
- The calibration block shall contain a vertical slot or through-hole at each end. The purpose is to verify during the calibration scan that the gate has extended past the center line. The reflecting face of this reflector shall be coincident with the centerline of the calibration block.
- The acoustic velocity of each pipe material shall be determined in the same plane as the pipe axis using SH (Horizontally Polarized) shear waves polarized to simulate particle displacement during actual examination conditions. Measurements shall be made using parallelograms machined to represent the lowest and highest examination angles. Two complete sets of parallelograms shall be taken from each pipe section sets shall be separated by 180°. This data shall be considered during transducer design and be recorded in procedure logical report format and submitted to the Company for determination of calibration block quantities and dissimilar material velocity examinations (i.e., transition welds).
- Calibration standards shall be certified by the machine shop and a report shall be provided to the Company verifying the tolerance to design actual for each of the calibration reflectors. In addition, the Contractor shall ultrasonically verify the signal response from like kind reflectors on upstream versus downstream sides; a report demonstrating compliance to the above shall be provided to the Company.

Table 2-3 outlines the flat bottom holes (FBH) and deep surface notches measurements for the principal calibration reflector for fusion defects according to design type.

Table 2-3: Principal Calibration Reflector for Fusion Defect and Porosity Detection Requirements

Design Type	Wall Thickness	Principal Calibration Reflector for Fusion Defects	Porosity Detection
Stressed-Based Pipeline Design	≤ 1 in. (25 mm)	• 2 mm diameter FBH • 1 mm deep surface notches • 2 mm deep x 10 mm wide transverse notches • 3 mm deep TOFD outside diameter (OD) notches • 2 mm deep TOFD inside diameter (ID) notches	1.5 mm
	> 1 in. (25 mm)	• 3 mm diameter FBH • 1 mm deep surface notches • 2 mm deep x 10 mm wide transverse notches • 3 mm deep TOFD OD notches • 2 mm deep TOFD ID notches	2 mm
Strain-Based Pipeline Design	All	• 2 mm diameter flat bottom holes (FBH) • 1 mm deep surface notches • 2 mm deep x 10 mm wide transverse notches • 3 mm deep TOFD OD notches • 2 mm deep TOFD ID notches	1.5 mm

The central axis of each FBH calibration reflector shall coincide with the central axis of the sound beam interrogating it.

Machining tolerances for all calibration reflectors shall be less than or equal to the following:

- Hole diameter ± 0.1 mm
- Flatness of FBH ± 0.2 mm
- Angles ± 1 degree
- Notch Depth ± 0. 2 mm
- Notch Length ± 10%
- Center location ± 0.2 mm
- Hole depth ± 0.2 mm

2.3.2 Procedures

Ultrasonic examination shall be performed in accordance with a documented, detailed procedure technique approved by the Company. The Contractor shall provide an automatic ultrasonic examination procedure technique that meet the requirements of ASTM 1961, Section 6.7.

Approved procedures shall contain, as a minimum:

- the applicable information stated in this Specification
- information stated in ASME Section V, Article 4
- a description of the methodology used to investigate indications

The Contractor shall demonstrate the effectiveness of all proposed procedures and techniques to the Company prior to mobilizing each system to the project. The specific technique for each wall thickness will be assessed according to the performance requirements contained in Section 2.4 of this Specification. All project procedures/techniques must be approved prior to mobilization to the project. The Contractor shall not use any procedure or technique in the performance of the work that has not been approved by the Company. The Company shall be sole judge of the adequacy of the technique for the intended use.

Qualifying examinations shall be produced under site conditions and in the presence of the Company for each proposed procedure and/or technique. Such procedure acceptance testing shall be performed using Contractor weld procedure or welder qualification test welds. The qualification process shall be in accordance with API 1104 Section 11.4.4 and occur prior to the commencement of production welding.

The Company will notify the Contractor of its approval of each procedure and/or technique. Upon approval from the Company, the procedure becomes a mandatory requirement and changes are only permitted upon subsequent approval from the Company.

2.3.3 Techniques

Automated techniques, using either focused transducers or phased-array transducers, in combination with a minimum of A-scan, stacked A-scan presentations, and a fully automatic recording system, shall indicate accurately the circumferential location, length, and through-thickness location of indications as well as the continuity of acoustic coupling. The system analysis software shall be capable of determining the through-thickness height of indications with an accuracy ≤ 1.5 mm. System resolution shall be 1 mm of circumferential distance, and the system shall provide for encoder accuracy verification. Circumferential distance markers shall be provided at intervals not exceeding 1 cm of weld length.

2.3.4 Quality Management

The Contractor will submit a project-specific Implementation Plan together with a Quality Management Plan.

2.4 System Set-Up

Prior to commencing the ultrasonic examination, the system shall be optimized for field examination using the calibration standard established in Section 2.3 of this Specification.

2.4.1 Calibration Standard Scan

The calibration standard shall be used daily before beginning pipe weld examinations, after repairs to the system, and thereafter at intervals not exceeding 1 hour (or 10 welds, whichever comes first), and at the conclusion of the shift.

When changes are made to the setup (e.g., a change of wall thickness, transducer or wedge), then six acceptable consistency calibration scans are required.

The record copy of the calibration standard scan shall be included sequentially with the weld examination charts. The last weld number inspected and time at which it was performed should appear on each calibration chart. These charts shall be made available to the Company upon request.

2.4.2 Transducer Positioning and Primary Reference Sensitivity

Table 2-4 outlines the requirements for transducer positioning and primary reference sensitivity.

Table 2-4: Requirements for Transducer Positioning and Primary Reference Sensitivity

Topic	Description
Primary Reference Level	• The system shall be optimized for field examination using the calibration standard established in Section 2.3.1 of this Specification. • Each transducer shall be positioned at its operating distance away from the simulated weld centerline on the calibrated standard and adjusted to provide a peak signal from its target reference reflector in its examination zone. • The peak signal response shall be adjusted to approximately 80% of the full screen height for each channel. This gain level shall be the primary reference for that transducer and shall be recorded in the procedure (see Section 2.3.2 this Specification). • Variation and corrective actions to maintain calibration shall be recorded on a Company pre-approved form. • The noise shall be at least 20 dB weaker than the signal at the target path, and the electronic noise 40 dB weaker. • For the examination of welds when an alternate flaw acceptance criteria (ECA) is used, the signal discrimination between adjacent zones shall be a minimum 6 dB but not exceed 12 dB. • For the examination of all welds when a workmanship flaw acceptance criteria is used, the signal discrimination between adjacent weld body zones shall, where practicable, be a minimum 6 dB but never exceed 12 dB. For those zones examining the pipe surfaces a minimum of 6 dB discrimination is required.
Gate Settings	• Using the calibrated standard, each detection gate shall be set to cover a sound path which starts at least 5 mm before bevel configuration, and ends at least 1 mm past the weld centerline. • The gate start position and gate length with respect to the weld preparation for each detection channel shall be recorded in the procedure. • For mapping (stacked A-scan), the gate shall mimic the start positions above and extend past the weld geometry where practicable.

Topic	Description
Gate Recording Threshold	• The recording threshold of each planar detection channel shall be 40% of full screen height when on the peak signal response from the target FBH or surface notch. • The recording threshold of each porosity detection channel shall be 10% of full screen height when the 1.5 mm diameter FBH.
Data Display	• Channel output signals shall be arranged in the data display and PDF copy record in an order acceptable to the Company. • Time delays shall be applied to the signals to compensate for different transducers circumferential positions relative to the circumferential zero point and subsequent distance markers. • Details of the delays applied and the chart arrangement shall be recorded in the procedure. • Variations and corrective actions to maintain calibration shall be recorded on a Company pre-approved form
Circumferential Scanning Velocity	• Scanning velocity shall not exceed values determined by the following calculation: $V_c \leq W_c * PRF / 3$ ▪ V_c is the scanning velocity ▪ W_c, is the narrowest -6dB beam width at the appropriate operating distance(s) of all transducers in accordance with the design requirements ▪ PRF is the pulse repetition frequency per transducer
Circumferential Scanning Direction	• The circumferential scanning direction should be marked on the pipe with sufficient extent as to not be covered by coating application.
Operating Log	• A log shall be kept of adjustments, changes to measurements, dB changes or other changes from those stated in the original technique. • Replacements will be documented (e.g., major system components, transducer wedge change-outs, transducer change-outs). • Transducer details shall include angle, frequency, serial number, diameter, and focal position if focused.

2.4.3 Calibration Qualification

Table 2-5 outlines the requirements for calibration.

Table 2-5: Calibration Requirements

Topic	Description
Detection Channels	• With the system optimized, the calibration standard shall be scanned in the multiplexed mode. • The recording medium shall indicate 70-100% (within specified tolerance) of full screen height signals from each calibration reflector recorded in their correct position assigned on the recorder chart. • The circumferential positional accuracy of the recorded reflectors relative to each other shall be within ± 2 mm.

Topic	Description
	• A calibration acceptable to the Company shall be used as the examination quality standard to which subsequently produced calibration charts shall be judged for acceptability. • Calibrations shall be performed at the same scanning speed as the weld examination – no stop/starting or rocking will be allowed, as this is intended to be a representative dynamic scan.
Coupling Monitor Channels	• Amplifier gain shall be adjusted when the system is mounted on the standard production weld to produce a maximum echo height of 80% from the full "vee" path, when using separate coupling monitors, or 80% full screen height and up to a maximum of +8 dB transmitted signal when in through-transmission mode. • The recording gate threshold level shall be a minimum of 20% of full screen height to a maximum 80% of full screen height. • For PA configurations, a methodology shall be established to confirm transducer coupling of all the elements in each array. • The defined methodology must include at least two additional through-transmission coupling sequences one transmitted from upstream to downstream and one transmitted from downstream to upstream. • The re-examination of the calibration standard with its surface wiped dry shall produce a record showing a lack of coupling (i.e., absence of recording signal). This shall be performed at least once per day.
Measurement to Assess Transducer Wear	• The Contractor shall provide baseline height measurement for the transducer case prior to the start of field weld examinations. • An accurate (± 0.1 mm) measurement shall be made of the case height at each of the corners of each transducer. These measurements shall be recorded on a Company approved form for a comparison of periodic measurements taken throughout the project to assess transducer wear. • The frequency of checks shall be defined in the procedure. • An ongoing transducer performance monitoring process may be used as a substitute for physical measurements, if approved by the Company.

2.5 Ultrasonic Testing of Girth Welds

The following sections outline key requirements for ultrasonic examination of girth welds including visual examination, weld marking, surface conditions, reference line, monitoring system performance, and re-testing.

2.5.1 Visual Examination

At the option of the Company, the Contractor or designate should confirm by visual examination, at suitable intervals and with a slip gauge, that the pipe bevel dimensions and alignment prior to welding conform to the dimensional tolerances of the ultrasonic testing procedure. Any differences in dimensions or alignment observed during setup and scanning should be reported to the appropriate Company representative.

2.5.2 Weld Marking

The Contractor shall permanently identify each weld with a unique weld number following the weld number system provided by the Company. The weld number shall be positioned on the pipe surface on the work side of the pipe in a manner agreed by the Company. Weld numbers shall be large enough to be clearly visually identified from a distance of 10 feet.

2.5.3 Surface Conditions

The scanning surface shall be free of weld spatter and other irregularities that may interfere with the movement of the transducers, the coupling, or the transmission of acoustic energy into the material.

Additionally, pipe coating shall be cutback for a minimum distance of 5 in. (125 mm) from the original bevel face. Spiral or long weld seams shall be ground within 0.5/-0 mm of the pipe surface for a distance measured along the length of the pipe of 5 in. (125 mm) from the original bevel face. This is to ensure that no transducers are lifted from the pipe surface during the scanning operation.

2.5.4 Reference Line

Prior to welding, the Contractor shall scribe a reference line on the pipe surface at a standardized distance from the weld centerline with an accuracy of ± 0.5 mm from the centerline of the weld preparation and on the examination band side.

The reference line shall be used to ensure that the band is adjusted to the same distance from the centerline to replicate the calibration standard. The tolerance to ideal positioning shall not exceed ± 0.5 mm. The 12 o'clock position shall also be clearly marked on the pipe to indicate the start position (0 in./cm) position of the scan.

The Contractor shall take into account the circumferential shrinkage of the girth weld during the design and calibration sequences. Shrinkage is determined by scribing a reference line on both pipe ends for the first 10 welds, then measuring the distance in between them after welding.

2.5.5 System Monitoring

Table 2-6 outlines the requirements for monitoring system performance.

Table 2-6: Verifying System Performance Requirements

Topic	Description
Scanning Sensitivity	• An additional 4 dB of gain should be added globally to the system for weld examination to compensate for differences in coupling efficiencies between the calibration standard and the production pipe. This additional gain shall be removed during calibration. If additional 4dB is not added, a transfer correction shall be used. • During production weld examination, with the Company's approval, the system may be operated at a higher gain to ensure detection of defects, or to account for excessive pipe surface roughness. • This additional scan gain shall only be applied to planar detection sequences. The porosity detection sequences and TOFD sequence shall not have additional gain added These sequences already account for coupling differences due to their higher gain and lower recording threshold requirements.
Circumferential Position Accuracy	• The position accuracy of the chart distance markers shall be validated twice during each working shift. • The scanner shall travel from the zero position with the scanning frame coincident with the pipe. • At all o'clock positions, the index marks on the scanning frame and the pipe must be aligned. • The chart shall then be compared to circumferential distance measured with a diameter tape; chart accuracy shall be within ±1 cm or better.
Temperature Control	• The Contractor shall maintain a stable transducer wedge temperature between the calibration scan and scanning the weld. This shall be monitored using a thermocouple embedded in a dummy transducer within the array, or in one of the active transducer wedges used in conjunction with a digital temperature gauge. • The difference between the temperature of the transducers on the production weld and the temperature of the transducers when scanning the calibration block shall be monitored and must be within 50°F (10°C) variance. • The temperature shall be recorded on all the hard copy printouts and be present in the electronic data. Alternative wedge property monitoring techniques may be considered by the Company prior to mobilization. • For testing at temperature extremes in very hot or very cold conditions, the calibration block may need to be heated or cooled so that the array is maintained within a 50°F (10°C) variance when completing calibration in, weld scan, and calibration out cycles.

2.5.6 Re-Examination

Table 2-7 outlines the conditions in which re-examination is required.

Table 2-7: Re-Examination Conditions

Item	Details
Calibration Qualification and Sensitivity	Welds examined that do not meet the requirements of Section 2.4.3 of this Specification shall be re-inspected.
Coupling Losses	Welds examined exhibiting coupling losses with a length exceeding 12 mm or adjacent coupling sequences shall be re-inspected.
Scanner Slippage	Scans shall not be acceptable where any slippage occurs. Where slippage is noted, the scanner shall be adjusted to correct the problem and the scan shall be repeated.
Weld Repairs	Repaired areas shall be tested by automated ultrasonic examination using the appropriate SMAW configuration, or if not practicable, by using manual ultrasonic testing per APPENDIX C of this Specification.
Temperature Variance	Welds examined that do not meet the requirements of Section 2.5.5 of this Specification shall be re-inspected.
Other Conditions	When conditions exist where data collection is impaired or data is lost, the weld shall be re-tested with no additional compensation to the Contractor. The operator shall write down the reason for impaired data and relay that to the Company.

2.6 Evaluation of Indicators

Automated Ultrasonic Weld Examination should be performed at a scanning sensitivity of 80% screen height reference sensitivity plus 4 dB when using the pulse-echo technique, as stated above. Evaluation sensitivity should be the same as scanning sensitivity. Evaluation level screen height (recording threshold) should be 40% of full screen height using the automated pulse-echo technique. Other automated techniques, reference reflectors, evaluation sensitivities, and evaluation levels may be used if demonstrated to be equivalent to the pulse-echo technique for the detection and evaluation of weld imperfections.

2.6.1 Imperfections

All welds will be inspected initially to API 1104 Section 9.6; if the weld fails that criteria for reasons other than a crack, the weld may then be evaluated to API 1104 – Appendix A, "Alternative Acceptance Criteria" (refer to DOT Regulations 49 CFR Part 192.241 or CFR 195.228, as appropriate).

Indications from weld imperfections shall be evaluated according to defect acceptance criteria defined by the Company using an Engineering Critical Assessment carried out according to API 1104, Appendix A.

Evaluations shall be completed immediately after examination of the weld. Failure to meet the API 1104 – Appendix A, "Alternative Acceptance Criteria" will then require weld repair and re-examination.

When evaluating imperfections following the acceptance criteria detailed in Section 9.6.2 of API 1104, the length of imperfections shorter than the width of the interrogating sound beam shall account for beam spread. For imperfections longer than the interrogating beam width, the point where the signal reduces to the 40% reporting threshold shall be considered the end of the imperfection.

When evaluating imperfections following the API 1104, Appendix A length interaction criteria, the ends of the indications are to be determined from the points where the signal reduces in amplitude to two times the background noise level.

For imperfections assessed to the acceptance criteria using only the data recorded in the volumetric sequences, that assessment shall be limited to porosity imperfections. Imperfections from inter-pass incomplete fusion must be assessed at a sensitivity level corrected to be equivalent to 40% of full screen height when the peak signal response from a target 2 mm FBH is 80% of full screen height.

2.6.2 Shielded Metal Arc Welding (SMAW) Root Zone Buried vs. Open Surface Classification

Indications in the 70˚ root sequence must have a corresponding signal ≥ 6 dB in 60˚ root sequence to be interpreted as surface breaking, in addition to meeting the following requirements. Indications occurring simultaneously in root 60˚ and root 70˚ sequences must have the transit times compared to the calibration notch transit times to aid correct classification as buried or surface breaking. Indications occurring > 0.5 mm prior to the respective notch Time of Flight (TOF) time must be reviewed in the A-scan map display. The indication must to be classed as buried if there is a simultaneous signal evident from the face of the root bead. The highest amplitude in the defect area will be evaluated. Multiple indications will be assessed separately.

2.7 Records and Reports

Table 2-8 outlines the record and report requirements for ultrasonic examination of girth welds.

Table 2-8: Record and Report Requirements

Topic	Description
Weld Examination Record	• An electronic copy record of each weld and calibration scan shall be provided to the Company. • The Contractor shall supply the Company the raw data for both calibration and weld scans daily for ongoing audit purposes. • Where practicable, this data shall be uploaded to a suitable electronic file transfer site FTP which the Company auditor has internet access to. • When the Contractor has no internet access, the raw data for both calibration and weld scans for a period no longer than 3 production days shall be copied to suitable electronic storage device and provided to the Company auditor.
Interpretation of Weld Examination Record	• Areas in the AUT data with a corresponding pulse-echo response will be evaluated and given a disposition by the operator as to relevant/non-relevant indication. This area will be highlighted on the strip chart and have an associated comment in the comments section of the AUT data. • Areas with signals resulting from weld geometry only need highlighting in the data when

Topic	Description
	their length exceeds the acceptable imperfection length.
Weld Acceptance from Examination Record	• A weld shall be considered acceptable when the weld examination shows imperfections that do not exceed the acceptable values, as given by the Company. Acceptable values are provided either in the contractor or prior to the start of work. • The Contractor shall submit ultrasonic weld interpretation reports to the Company daily, as directed by the Company. • The Contractor shall ensure that all electronic data files and electronic files are further identified with the following: ▪ Spread Identification ▪ Project name ▪ Work order number ▪ Date & time ▪ Operator's name & signature ▪ Examination Unit Number ▪ Weld number & type (weld configuration/transition) ▪ Pipe material, diameter, and wall thickness ▪ AUT Procedure ▪ Acceptance criteria (ECA/Workmanship) • All reporting shall be catalogued by consecutive weld number in binders
Data Management	• Back-ups of all electronic data shall be made for audit purposes on a daily basis with a minimum of two back-ups of each file on separate mass storage media. • The working computer system disk shall not be considered as a back-up.
Report Guidelines	• Equipment performance logbooks, daily reports (Weld Log), and Repair Lists will be presented to the Company in hard copy and/or electronic format. • Evaluation of the acceptability of every weld examination shall be reported on the "NDE Daily Report". The NDE Daily Report form will be the only form used for NDE (UT, VT, RT, MT, and PT) for weld accepted/rejected status. • The Contractor will ensure that GPS/Chainage coordinates are recorded with the applicable weld information on NDE Daily Report for all tie-ins, repair welds and every 650 feet (200m) intervals for main and poor boy, if applicable. • The NDE Supervisor shall collect all reports from the NDE Inspectors and document weld status in a database.
Archives	• No later than 3 months after completion of the project, a copy of all of the raw weld and calibration data shall be packaged together with a weld interpretation log and a raw data viewer program to provide an archive record. • The viewer software shall allow reconstruction of the weld data files in an identical manner to that viewed by the system operator at the time of examination.

Table 2-9 outlines the supporting documentation required for the above.

Table 2-9: Required Supporting Documentation

Record Type	Requirements
Calibration Standard Records	• specific pipe details • acoustic velocity reports • dimensions, position, and angle of reference reflectors • metrology records
Transducer Records	• make, date of manufacturing, and serial number • nominal dimensions • nominal frequency • height & wear • performance records
Ultrasonic System Records	• system description • make & model number of units • operating procedure • technique(s) detailed • operator log • consistency calibrations • performance tests, e.g. signal to noise, linearity, and element continuity tests
System Operator Records	• copy of certifications • copy of eye exams • copy of experience records

2.7.1 Weld Repair List

Weld repair lists shall be provided to the Company in electronic and or hard copy format each working day. The time shall be specified by the Company and agreed to by the Contractor.

Repair lists shall report the weld quality, including outstanding weld repairs and/or weld cut-outs, of all welds completed by the prime Contractors' mainline welding crew. The daily cut off time shall be specified by the Company and agreed to by the Contractor.

3 VARIANCES

Any deviation must follow the appropriate TransCanada Management of Change (MOC) Variance Procedure (EDMS No. 7728702).

4 ROLES AND RESPONSIBILITIES

Table 4-1 below outlines the roles and responsibilities required for the use of this Specification.

Table 4-1: Roles and Responsibilities

Role	Responsibilities
Company	The Company is responsible for: • Ensuring all relevant information is provided to the Contractor(s) and Operator(s) • Oversight on all Ultrasonic Examinations
Contractor	• The Contractor is responsible for ensuring all relevant requirements of this Specification and all other relevant documents are met.
Supervisor	• The Supervisor shall be responsible for the conduct and performance of all ultrasonic personnel and for maintaining all equipment and supplies in reliable condition. • The Supervisor shall work closely with the Company's Senior Welding Inspector in the documentation of examinations completed and shall be responsible for all reports, interpretations, and evaluation. • The NDE Supervisor shall audit daily the electronic data to ensure that interpretations are consistent, informative, and concise, and this Supervisor shall be capable of technical support for NDE operations. The extent of data audit shall be approved by the Company.
Ultrasonic Operator	The Ultrasonic Operator is responsible for ensuring all relevant requirements of this Specification and all other relevant documents are met.

5 TRAINING AND QUALIFICATIONS

If required by the Company, the Contractor shall provide training (one day minimum) for Company Inspectors on the techniques of ultrasonic examination. This training shall be at a date and location determined by the Company and shall occur prior to the start of production welding.

Table 5-1 outlines the personnel qualifications for ultrasonic examination of girth welds.

Table 5-1: Personnel Qualifications

Personnel	Qualifications
Supervisor	• The NDE Supervisor shall be approved by the Company based upon experience, technical knowledge, and NDE qualifications for the duties to be performed. • Supervisors shall be qualified by examination and certified as a Level II or III in the “Ultrasonic” method in accordance with the requirements of ASNT-SNT-TC-1A, ACCP, or CP-189 and shall submit their records of certification. • At a minimum, all Level III personnel shall be qualified to ANSI/ASNT Standard CP-189 or ACCP in the Ultrasonic method, and shall submit their records of current certification.

Personnel	Qualifications
Ultrasonic Operators	• The Company reserves the right to assess the competency of ultrasonic operators for manual examination using qualification welds containing defects. • Ultrasonic operators must demonstrate their ability to detect and characterize typical indications and determine their acceptance according to the API 1104, Section 9.6.2 criteria and shall be approved by the Company. At the discretion of the Company, this process may be waived in lieu of an alternate approach. • The Company shall be sole judge of operator performance. • Ultrasonic operators shall be qualified by examination and certified as a Level II or III in the "Ultrasonic" method in accordance with the requirements of ASNT-SNT-TC-1A, CP 189 or ACCP, and shall submit their records of certification. • Operators shall have completed a minimum of 40 hours training in automatic testing, including practical and theoretical aspects pertinent to the equipment and general configurations to be examined. This training shall be documented and the records shall be provided to the Company. • An operator's project experience shall include stand-alone automated ultrasonic testing of a minimum 1000 pipeline girth welds. • Alternate experience in lieu of the above requirements are subject to Company approval.
Contractors	• The Company will only use Contractors who have been approved in accordance with TEP-NDT-SQP System Qualification Procedure (EDMS No. 8906013).

6 SAFETY CONSIDERATIONS

No incremental Safety Considerations are identified for this Specification.

7 ENVIRONMENTAL CONSIDERATIONS

No incremental Environmental Considerations are identified for this Specification.

8 GLOSSARY

Definitions related to this Specification can be found in Appendix D.

9 REFERENCES

This document relies on a number of references to legislation (act, statutes, and regulations), certificates, and orders and may include directives, guidelines, standards, and codes to the extent they contain legally binding requirements for TransCanada.

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 9-1.

Table 9-1: External and Internal References

Document No.	Title
Legal Requirements	
DOT 49 CFR Part 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards and any amendment, supplement, or errata issues by the United States Department of Transportation
DOT 49 CFR Part 195	Transportation of Hazardous Liquids by Pipeline and any amendment, supplement, or errata issued by the United States Department of Transportation
Industry Codes and Standards	
API 1104	Welding of Pipelines and Related Facilities
ANSI/ASNT-CP-189	ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel
ASNT-SNT-TC-1A	ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel
ASTM E164	Practice for Ultrasonic Contact Examination of Welds
ASTM E317	Practice for Evaluation Performance Characteristics of Ultrasonic Pulse- Echo Testing Systems without the Use of Electronic Measurement Instruments
ASTM E494	Practice for Measuring Ultrasonic Velocity in Materials
ASTM E316	Standard Terminology for Non Destructive Examinations
ASTM E1961	Standard Practice for Mechanized Ultrasonic Testing of Girth Welds Using Zonal Discrimination with Focused Search Units
BS EN 583-6: 2008	Non-destructive testing. Ultrasonic examination. Time-of-flight diffraction technique as a method for detection and sizing of discontinuities
Electrical Supply Industry Standard ESI 98-2 Issue 1 Dec 1979/R1998	Ultrasonic Probes: Medium Frequency Miniature Shear Wave, Angle Probes
BS EN 12668	British Standard, Characterization and Verification of Ultrasonic Examination Equipment; Part 1 Instruments, Part 2 Transducers, Part 3 Combined Equipment
ASME Section V	Nondestructive Examination
Internal References – Documents that Reference this Specification	
EDMS No. 1001828336	TEN-NDT NDT Standard (CDN-US-MEX)
EDMS No. 1001828218	TES-WELD-API Welding of Pipelines and Facilities Specification (US-MEX)

Document No.	Title
EDMS No. 6717380	TES-INSERV-API Welding on In-Service Pipelines Specification (US-MEX)
Internal References – Documents Referenced by this Specification	
EDMS No. 8906013	TEP-NDT-SQP System Qualification Procedure

10 DOCUMENTATION AND RECORDKEEPING

Table 10-1 details the documentation to be approved by the Company prior to System Mobilization. Refer to Section 2.7 for further details.

Table 10-1: Documentation to be Approved by the Company Before System Mobilization

Item #	Documentation Required	TES-NDT-UT Reference	Company Representative Signoff
1	Project Specific Implementation Plan	2.3.4	
2	Quality Plan	2.3.4	
3	System and Operator Certifications	5	
4	General AUT Procedure	2.3.2	
5	Manual Ultrasonic Procedure	APPENDIX C	
6	Project Specific Examination Designs/Techniques	2.1	
7	Calibration Block Drawings	2.3.1	
8	Calibration Block Metrology and Ultrasonic Response Reports	2.3.1	
9	Pipe Material Acoustic Velocity Measurement Reports	2.2	
10	System Linearity Reports	2.2	
11	Ultrasonic Transducer Performance Reports	2.4.3	
12	Signal to Noise Reports	2.2	

11 DOCUMENT HISTORY

Rev.		
00	**Description**	**Effective Date**
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-11-01
	Rationale Statement	**Responsible Engineer**
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Simon Hsu Sr. Welding Engineer
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the NDE group and to make it more easily accessible to those who use it.	Simon Hsu Sr. Welding Engineer

12 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A.
Industry Standards	
N/A	N/A.
General	
N/A	This Specification is a new document.

13 APPROVALS

APPROVALS		
Originator: Salvatore Delisi, Senior Welding Technologist Welding and Materials Engineering	Signature	10/27/16 Date
Reviewer: Jason Althouse, Senior NDE Technologist Welding and Materials Engineering	Signature	10/27/16 Date
Responsible Engineer: Simon Hsu Sr. Welding Engineer Welding and Materials Engineering	Simon Hsu Signature 10/27/2016 Date	

APPENDIX A EXAMINATION DESIGN REQUIREMENTS GAS METAL ARC WELDS (GMAW)

A-1 PURPOSE

This appendix details the examination design requirements for automated ultrasonic examination of gas metal arc welds produced in the specified weld bevel.

A-2 SCOPE

This appendix applies to mechanized ultrasonic examination of gas metal arc welds made with an internal root bead or with all passes deposited externally. This applies to pipe having a nominal wall thickness of 0.283 in. (7.2 mm) and greater.

A-3 APPLICABLE STANDARDS

Ultrasonic examination shall also meet the requirements of API 1104 and any amendment, supplement, or errata issued by API.

A-4 APPLICABLE WELD BEVEL

This design is applicable to mechanized gas metal arc weld bevel examination designs shown in Appendix Figure A-1.

A-5 ULTRASONIC PARAMETERS

Ultrasonic parameters (transducer number, angle, frequency, beam size and position) shall be selected for each zone of the specified weld bevel, beginning in the weld root and finishing at the weld cap.

A-5-1 ROOT ZONE

Welds with an Internal Root Bevel (37.5° Internal Bevel) and a weld pass deposited internally, see Appendix Figure A-1(a). One ultrasonic zone shall be required with the following parameters:

Appendix Table A-1: Ultrasonic Zone Parameters (Root Zone (1))

Wall thickness	Angle (degrees)	Frequency (MHz)	Zone Size (mm)	Surface position
≤ 0.314 in. (8 mm)	52.5 ± 2.5	min. 4 max. 8	min. 2.0 max. 2.5	1.5 skip
> 0.314 in. (8 mm)	52.5 ± 2.5	min. 4 max. 8	min. 2.0 max. 2.5	0.5 skip

Weld with all Passes Deposited Externally (0° Land), see Appendix Figure A-1(b). One ultrasonic zone shall be required with the following parameters:

Appendix Table A-2: Ultrasonic Zone Parameters (Root Zone (2))

Wall thickness	Angle (degrees)	Frequency (MHz)	Zone Size (mm)	Surface position
≤ 0.314 in. (8 mm)	70.0 ± 2.5	min. 5 max. 6	Min. 1.5 max. 2.0	1.5 skip
> 0.314 in. (8 mm)	70.0 ± 2.5	min. 5 max. 6	min. 1.5 max. 2.0	0.5 skip

A-5-2 CROSS-PENETRATION ZONE

0° Bevel - Welds with an Internal Root Bevel only. Refer to Appendix Figure A-1(a) for bevel sketch. One ultrasonic zone shall be required with the following parameters:

Wall thickness	Angle (degrees)	Frequency (MHz)	Zone Size (mm)	Surface position
≤ 0.314 in. (8 mm)	70.0 ± 2.5	min. 5 max. 6	min. 1.5 max. 2.0	1.5 skip
> 0.314 in. (8 mm)	70.0 ± 2.5	min. 5 max. 6	min. 1.5 max. 2.0	0.5 skip

Appendix Table A-3: Ultrasonic Zone Parameters (Cross-Penetration Zone)

A-5-3 HOT PASS ZONE

Welds with an Internal Root Bevel (45° or 52° Hot Pass Bevel):

- For a hot pass with a bevel offset less than 2.5 mm, one ultrasonic zone is required with a -6dB beam size of 3.5 mm.
- For a hot pass with bevel offset of 2.5 mm and greater, this zone shall be divided in 2 sub-zones (refer to Appendix Figure A-1(a)) and two transducers shall be required with the following parameters.

Appendix Table A-4: Ultrasonic Zone Parameters (Hot Pass Zone (1))

Wall thickness	Angle (degrees)	Frequency (MHz)	Zone Size (mm)	Surface position
≤ 0.390 in. (10 mm)	min. 50 max. 55	min. 4 max. 5	min. 2.5 max. 3.0	1.5 skip
> 0.390 in. (10 mm)	min. 50 max. 55	min. 4 max. 5	min. 2.5 max. 3.0	0.5 skip

Weld with all Passes Deposited Externally (Radius Hot Pass)

- Refer to Appendix Figure A-1(b) for bevel sketch. One ultrasonic zone shall be required with the following parameters:

Appendix Table A-5: Ultrasonic Zone Parameters (Hot Pass Zone (2))

Wall thickness	Angle (degrees)	Frequency (MHz)	Zone Size (mm)	Surface position
≤ 0.390 in. (10 mm)	min. 50 max. 55	min. 4 max. 5	min. 2.0 max. 2.5	1.5 skip
> 0.390 in. (10 mm)	min. 50 max. 55	min. 4 max. 5	min. 2.0 max. 2.5	0.5 skip

A-5-4 FILL(S) AND CAP ZONES[1]

The number of transducers for the fill(s) and cap zones, and their parameters, are linked directly to the pipe wall thickness. Typical bevel sketches are shown in Appendix Figure A-1.

For wall thickness < 0.314 in. (8 mm) one focused 70 ±2.5° shear wave transducer shall be used.

For wall thickness ≥ 0.314 in. (8 mm), but < 0.500 in. (12.7 mm):

- Two focused 70° (±2.5°) shear wave transducers, or a combination of one focused 65°- 70° shear wave transducer for the cap zone, and a single tandem arrangement for the fill zone shall be used.
- The -6 dB beam height selected for the cap zone shall have a dimension equal to or greater than the fill zone immediately below it.
- The preferred tandem configuration is shown in Appendix Figure A-2 and acceptable tandem combinations are specified in Appendix Table A-6.

No individual -6 dB beam size shall exceed 3.5 mm

For wall thickness ≥ 0.500 in. (12.7 mm) and larger:

- The cap zone shall be considered as having a 3.0 mm vertical extent and where practicable be inspected using a 65° to 70° (±2.5°) pulse echo, or creeping wave transducer, typically with a minimum -6 dB beam height of approximately 3.0 mm.

[1] For all wall thicknesses, the cap zone reference reflectors will consist of a 1 mm surface notch and a 2 mm FBH. The primary reference amplitude for the cap zone will be the response from the 2 mm FBH.

- The remaining bevel dimension extending from the top of the hot pass to the bottom of the cap zone (outside pipe surface minus 3 mm) shall be divided equally into fill sub-zones, with the following conditions:
    - The fill sub-zone immediately below the cap zone shall have a -6 dB beam height equal to or less than the cap zone dimension; and
    - No individual -6 dB beam size shall exceed 3.5 mm.
    - Each sub-zone shall be inspected using one of the suitable tandem combinations specified in.

Appendix Table A-6: Tandem Configurations

Fill Bevel Angle (degrees)	Transmitter Angle (degrees)	Receiver Angle (degrees)
4	38 - 50	Transmitter Angle + 8 (46 - 58)
5	38 - 48	Transmitter Angle + 10 (48 - 58)
6	38 - 46	Transmitter Angle + 12 (50 - 58)
7	38 - 44	Transmitter Angle + 14 (52 - 58)
8	38 - 42	Transmitter Angle + 16 (54 - 58)
9	38 - 40	Transmitter Angle + 18 (56 - 58)
10	42-48	Transmitter Angle + 20 (62 - 68)

A-6 POROSITY TRANSDUCERS

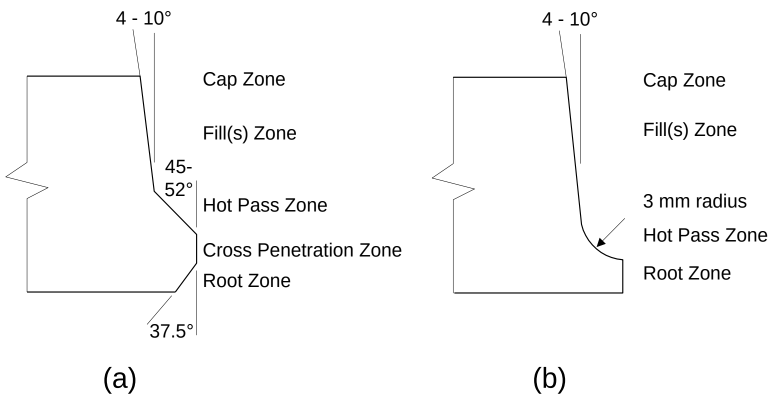
For the detection of porosity, the weld shall be divided into equal zones each not exceeding 3.5 mm, and examined using transducers with the following angles and frequencies:

- Root zone: One 65° to 72° transducer having a frequency between 5 and 7.5 MHz
- All other zones: 45° to 55° transducer/s having a frequency of 4.5 and 7.5 MHz.

A-7 TRANSVERSE CRACK DETECTION (SEE FIGURE A-3)

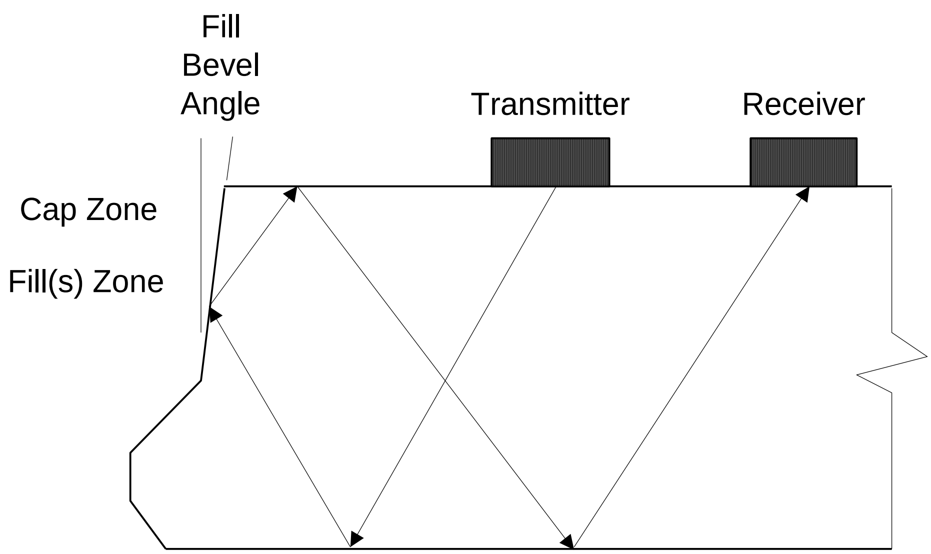
Two pairs of 45° to 70° transducers positioned at 20° to 60° from the weld axis in a cross-configuration shall be used to detect transverse cracks. The signal shall be sent from the transducer on the upstream side of the weld and received by the downstream transducer. One pair of transducers shall interrogate the upper half of the weld while the other pair interrogates the lower half. Coupling shall be monitored by sensing through-transmission diagonally across the weld.

FIGURES



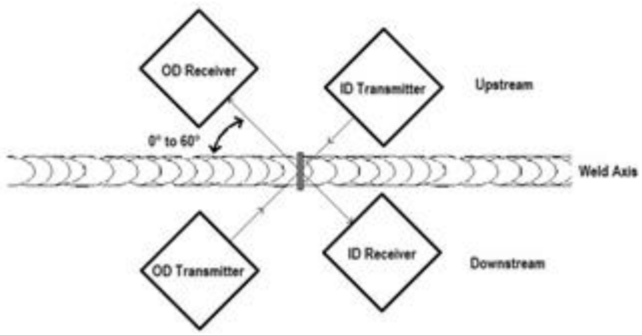
Appendix Figure A-1: Bevel Designs

(a) Weld with Internal Root (b) Weld with all Passes Deposited Externally



Appendix Figure A-2: Preferred Tandem Sound Path

Note: Shown for a weld with an internal root pass, same sound path for a weld with all passes deposited externally. When mechanically achievable the sound path should as short as practical; in the example above the receiver could be in front of the transmitter.



Appendix Figure A-3: Sound Paths for Transverse Crack Detection

APPENDIX B EXAMINATION DESIGN REQUIREMENTS WELDS IN FACTORY BEVEL (SMAW & FCAW)

B-1 PURPOSE

This appendix details the examination design requirements for automated ultrasonic examination of welds produced in the factory bevel.

B-2 SCOPE

This appendix applies to mechanized ultrasonic examination of arc welds made in pipe having a nominal wall thickness≥ 6.4 mm.

B-3 APPLICABLE STANDARDS

Ultrasonic examination to this procedure shall also meet the requirements of API 1104 and any amendment, supplement, or errata issued by API.

B-4 APPLICABLE WELD BEVEL

This design is applicable to the standard end preparation of pipe as shown in Appendix Figure B-1 of this document.

B-5 ULTRASONIC PARAMETERS

Ultrasonic parameters (transducer number, angle, frequency, beam size and position) shall be selected for each zone of the specified weld bevel, beginning in the weld root and finishing at the weld cap.

B-6 ROOT ZONE (0° BEVEL)

Two ultrasonic zones shall be required with the following parameters:

Appendix Table B-1: Ultrasonic Zone Parameters (Root Zone)

Wall thickness	Angle (degrees)	Frequency (MHz)	Zone Size (mm)	Surface position
≤ 0.314 in. (8 mm)	70.0 ± 2.5	min. 5 max. 6	min. 1.5 max. 2.5	1.5 skip
	60.0 ± 2.5			
> 0.314 in. (8 mm)	70.0 ± 2.5	min. 5 max. 6	min. 1.5 max. 2.5	0.5 skip
	60.0 ± 2.5			

B-7 HOT PASS ZONE (30° BEVEL)

One ultrasonic zone shall be required with the following parameters:

Appendix Table B-2: Ultrasonic Zone Parameters (Hot Pass Zone)

Wall thickness	Angle (degrees)	Frequency (MHz)	Zone Size (mm)	Surface position
0.314 in. (8 mm)	60.0 ± 2.5	min. 4 max. 6	min. 2.5 max. 3.5	1.5 skip
0.314 in. (8 mm)	60.0 ± 2.5	min. 4 max. 6	min. 2.5 max. 3.5	0.5 skip

B-8 FILL(S) AND CAP ZONES

The number of transducers for the fill(s) and cap zones, and their parameters, are linked directly to the pipe wall thickness.

B-8-1 WALL THICKNESS < 0.354 IN. (9 MM)

Two focused 60±2.5° transducers shall be used.

No individual -6 dB beam size shall exceed 3.5 mm.

B-8-2 WALL THICKNESS ≥ 0.354 IN. (9 MM)

The number of sub-zones (n), and focused 60V (±2.5°) shear wave transducers and their -6 dB beam heights shall be determined by the formula:

$$n = (WT - RH) / (\cos(A)*h) = (WT - 3) / (0.866*h)$$

where, A is the bevel angle (30° for a standard bevel), WT is the wall thickness in mm, RH is the vertical displacement to account or the root and hot pass (assumed as 3 mm), and h is -6 dB beam height such that:

No individual -6 dB beam size shall exceed 3.5 mm.

B-9 POROSITY TRANSDUCERS

For the detection of porosity, the weld shall be divided into equal zones each not exceeding 3.5 mm, and examined using transducers with the following angles and frequency.

- Root zone: One 60˚ or 70° transducer having a frequency between 5 and 7.5 MHz.
- All other zones: 45˚ to 55° transducers having a frequency of between 5 and 7.5 MHz.

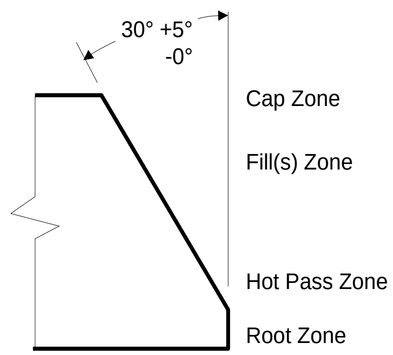
B-10 TIME OF FLIGHT DIFFRACTION (TOFD)

For a given pipe wall thickness, the transducer angle, frequency and damping characteristics shall be selected to optimize detection and to limit the depth of the lateral wave below the surface to a maximum of 4 mm, giving consideration to the index-to-index spacing and the maximum width of the weld reinforcement.

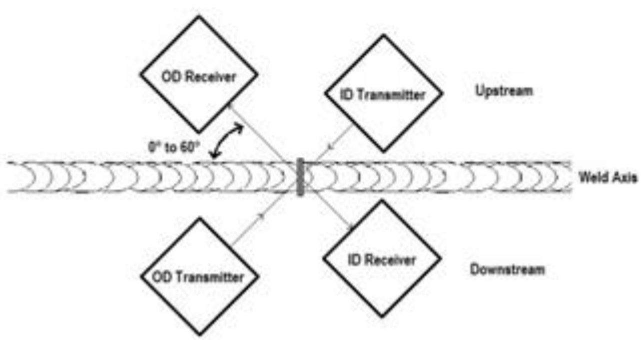
B-11 TRANSVERSE CRACK DETECTION (SEE FIGURE B-2)

Two pair of 45° to 70° transducers positioned at 20° to 60˚ from the weld axis in a cross configuration shall be used to detect transverse cracks. The signal shall be sent from the transducer on the upstream side of the weld and received by the downstream transducer. One pair of transducers shall interrogate the upper half of the weld while the other pair interrogates the lower half. Coupling shall be monitored by sensing through-transmission diagonally across the weld.

FIGURES



Appendix Figure B-1: Standard Bevel Design



Appendix Figure B-2: Sound Paths for Transverse Crack Detection

APPENDIX C REQUIREMENTS FOR MANUAL ULTRASONIC EXAMINATION OF WELDS

C-1 SCOPE

This Appendix applies to all pipeline assets, which are wholly owned and operated by TransCanada, as well as all partially-owned entities and/or joint ventures where TransCanada has operational control.

This Appendix applies to shear wave ultrasonic examination of welds made in pipe and/or plate having a nominal wall thickness greater than or equal to 0.250 in. (6.4 mm). When application of this appendix is utilized for pipeline girth weld repairs, the examination method originally used must verify defect removal prior to manual UT. Examination of wall thicknesses below 0.250 in. (6.4 mm) shall be addressed in a procedures provided by the NDE Vendor to the Company and approved by Materials and Welding Engineering prior to performing examinations.

C-2 NDE TECHNICIAN QUALIFICATION REQUIREMENTS

The Company shall have the right to examine the qualifications of all non-destructive testing personnel and to exclude individuals that, in the opinion of the Company, lack necessary training or experience for the work, or have demonstrated an inability to adequately perform the prescribed examinations. This evaluation may be in the form of the review of NDE technician qualification documents by Materials and Welding Engineering, via review of project documentation, or by direct observation. A Company authorized representative may also perform this evaluation. Incompetence or lack of diligence at any time may result in immediate termination from the project.

For the minimum qualification for personnel, referred to herein as Level II Ultrasonic Testing technicians, the following requirements shall be met:

- Personnel undertaking ultrasonic testing shall be qualified under TransCanada's Operator Qualification (OQ) program; in addition, they require certification to Level II or III of SNT-TC-1A, CP 189 or ACCP requirements.
- The status of NDE personnel indicating certifications obtained directly from ASNT can be verified here: https://asnt.org/certificant. Employer based NDE certifications WILL NOT be indicated on this website.
- Evidence of current Operator Qualification shall be provided to the Active Controller prior to work being performed. In the U.S., Company operator qualification records for Covered Tasks Veriforce Task ID 206 – Nondestructive Testing of Welds (Ultrasonic) shall be obtained from the NDE vendor or verified by confirmation on VeriSource website [https://www.veriforce.net/vs/login.aspx].

C-3 EQUIPMENT

The following equipment shall be available to perform the examination:

- Portable ultrasonic flaw detector having a linear presentation which meets the requirements of ASME Section V, Article 5.

- International Institute of Welding, IIW Type 1, or Type 2, calibration block.
- Transducers having a nominal frequency between 3.5, and 6.5 MHz, with an active crystal dimension no greater than 0.500 in. and refracted angles of 45°, 60°, and 70°. Transducers may be either a fixed configuration, or removable wedge types; where pure volumetric scanning is performed focused probes shall not be used. Where accurate defect height sizing is required focused transducers shall be used.
- Project specific ultrasonic calibration block containing 10% of wall thickness square notches (N10), one on OD and one on ID surfaces; a 0.100 in. diameter side drilled hole located at ½ wall thickness. Notches shall be separated by a minimum of 3.1 in. See API 1104 Section 11.4
- Couplant shall be water or a water-based gel; no oil based products shall be used. For cold weather application methanol may be added; the methanol mix must be recovered.

C-4 PROCEDURES

Ultrasonic examination shall be performed in accordance with a documented, detailed procedure, technique approved by the Company. A written procedure or technique sheet and instructions for each thickness and variation shall be produced which meets the requirements of API 1104, Section 11.4.2.2.

The ultrasonic technique shall be acceptable for the intended application. The Company reserves the right to judge of the adequacy of the technique for the intended use.

C-5 EQUIPMENT SET-UP

The equipment shall be set up and the weld scanned as follows:

- Transducers shall be as specified in the table below for the wall thickness to be examined.

Appendix Table C-1: Transducer Selection Criteria

Wall thickness (in.)	Examination Angles
Smaller than 0.375	70°
0.375 – 0.750 inclusive.	60 and 70°
Larger than 0.750	45, 60 and 70°

- Calibrate the range to represent a minimum distance of one and one half skip in the pipe material.
- With the project specific calibration block, produce a 3 point distance amplitude correction curve (DAC) using the N10 notches and adjust gain to produce peak DAC amplitude of 80 % FSH. At a distance of ¾ skip maximize the response from the 0.100 in side drilled hole, if the hole response is below DAC then adjust gain to produce an 80 % of FSH response.

When a project specific calibration block is not available, a similar calibration block may be utilized providing is transfer correction is determined and applied to the sensitivity as determined in the same method described in step (c).

C-6 EXAMINATION OF WELDS

C-6-1 BASE METAL EXAMINATION

A compression wave test of the parent material on both sides of the weld (minimum distance = 1.25, times the longest surface skip distance) shall be performed. All interfering partial and full beam reflectors shall be noted (datum location and distance from the weld edge) and recorded on the examination record.

Using a longitudinal wave transducer, adjust the second back-wall echo in the base material to at least 80 % of FSH and examine for laminar or stringer imperfections which may interfere with the transverse wave examination. All significant imperfections shall be recorded and, where practical, the transverse wave examination shall be modified to compensate for their presence. The area to be examined shall cover 100 % of the base metal though which the transverse wave will pass.

C-6-2 WELD METAL EXAMINATION

Manual ultrasonic weld testing shall be performed at a scanning sensitivity of DAC/TCG reference sensitivity plus 6 dB minimum. All indications that exceed 50% of DAC/ TCG screen height shall be evaluated. Evaluation sensitivity for manual ultrasonic weld testing should be DAC/TCG reference sensitivity plus 6 dB with an evaluation level for all indications at 50% of DAC/TCG screen height. After the reference sensitivity, scanning sensitivity, and evaluation sensitivity and levels have been established, they shall be qualified then incorporated into the final procedure and the final qualification report.

A 100% volumetric examination of weld metal and HAZ shall be performed. Examination techniques shall include:

- Add 6 dB of additional sensitivity for scanning purposes.
- Scan 100 % of the weld area using a zigzag scan pattern with the axis of the beam perpendicular to the weld.
- Ensure that the scan raster provides for a minimum 30 % overlap of the beam width.

C-6-3 EVALUATION

Indications exceeding 50 % DAC shall be evaluated as follows:

- The characteristic echo-dynamic behavior shall be used to classify the imperfection type.
- The through-wall location of the imperfection shall be determined by maximizing the signal response and calculating the depth using trigonometry.
- The length of the imperfection shall be measured using the 6 dB drop method and compared to the requirements of API 1104, Section 9.6.

C-7 AUDIT, AUDITOR, AND RIGHT TO AUDIT

All NDE operations are subject to audit by the Company. NDE audits shall be planned and conducted by a Company auditor with appropriate qualifications in non-destructive examination, on a periodic but random basis, to verify compliance with Specification and Contract requirements. The Company auditor shall have the right to examine all procedures, reports, and equipment both during and after method performance, complete an audit report, recommend disposition of any nonconformance, and suggest appropriate corrective actions when required. If the Company audit finds a required corrective action, these findings shall be addressed in a timely manner.

C-8 REPORTS

Defects found during examination shall be reported on the appropriate Contractor report form having a minimum of the following details:

- Weld identification
- Defect classification
- Defect length
- Location of the defect in the through thickness, with reference to the OD surface
- Side of the weld: upstream or downstream
- Position of the start of the defect from the top dead center of the weld in a clockwise direction when viewing the pipeline in the construction direction
- Maximum response from the defect expressed as a percent of FSH at reference gain setting
- General details, equipment used, operator identity and qualification level, date, and time
- Sketch
- Job number

APPENDIX D TERMS AND DEFINITIONS

Term	Definition for Terms
Active Controller	TransCanada's on-site lead technician
APEGA	Association of Professional Engineers and Geoscientists of Alberta
Authorized Representative	Individual designated by Materials Engineering to represent the Company for matters covered by this Specification.
ASME	American Society of Mechanical Engineers
Company, TCPL	TransCanada PipeLines Limited (Company) including their engineering agencies, inspectors and other authorized representatives.
Contractor	The ultrasonic inspection contractor engaged to perform work covered by this Specification.
DAC	Distance Amplitude Correction
dB (Decibel)	The dB is a logarithmic unit that describes a ratio of two measurements used in ultrasonic methods
FSH (Full screen height)	FSH is a measurement based upon a calibrated screen
HAZ (Heat-affected Zone)	Heat affected zone indicates the area which the welding process has changed the metallurgical properties of the parent material
NDE	Non-destructive Examination
Operator(s)	Operators of ultrasonic equipment. Ultrasonic operators shall be qualified and certified in accordance with the requirements of Level II Canadian General Standards Board, CAN/CGSB 48.9712 Qualification and Certification of Nondestructive Testing Personnel.
Operator(s)	Operators of ultrasonic equipment. Ultrasonic operators shall be qualified and certified in accordance with the requirements of Level II ASNT-SNT-TC-1A as a minimum and shall submit their records of certification. All operators shall be approved by the Company prior to the start of any work and shall qualify by demonstrating their ability to operate and interpret the results obtained from their ultrasonic inspection system. The qualification test shall be administered and witnessed by the Company prior to production welding.
Pipeline	A pipeline for the transmission of natural gas or hazardous liquids including laterals, branch connections, extensions, compressors, pumps, and related facilities as defined by 49 CFR 195, "Transportation of Hazardous Liquids by Pipeline" or by 49 CFR 192 "Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards"

Term	Definition for Terms
TOP	TransCanada Operating Procedure
Vendor	Any outside source hired by the Company to complete work

PURPOSE

This standard provides the key requirements for materials design, selection, and use.

SCOPE

This standard applies to the materials engineering design, selection, and use of all new high-pressure and low-pressure, non-sour, natural gas pipeline, compression, and metering facilities and non-sour liquid hydrocarbon pipeline, pump, metering and terminal facilities owned and operated by TransCanada in Canada, the United States, and Mexico.

This Standard does not apply to modifications to existing systems. For modifications to existing systems, the Designer shall determine the best practices providing that the modifications meet the intent of the current design requirements, and the requirements of the applicable regulations and industry standards.

This Standard does not include material requirements for the Energy business line.

The Responsible Engineer shall be contacted for clarification if needed.

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1 MATERIALS INFORMATION REQUIRED

This Standard provides the basis for materials selection and use in engineering design based on system pressure rating, design temperature, fracture toughness requirements, heat treatment requirements, manufacturer welding requirements, manufacturer NDE requirements, and equipment specific factors.

All general design requirements are provided in this Standard while all equipment specific factors are outlined in the referenced Specifications.

1.1 Pressure Rating

The Designer shall confirm the pressure rating of the system based on the following limits:

- Low-pressure systems: designed for pressures below PN 20 (1900 kPa) / ASME Class 150 (276 psi).
- High-pressure systems: designed for pressures at and above PN 20 (1900 kPa) / ASME Class 150 (276 psi).

These limits are subject to the specific project requirements and may be adjusted to suit project requirements in consultation with the Company's Materials Engineering department.

1.2 Design Temperature

The Designer shall verify the minimum design metal temperature (MDMT) based on the system region (outlined in Table 1-1 below). The MDMT for the U.S. is split into two zones (north and south) based on American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) data. Refer to APPENDIX C for a map of the temperature zones. The MDMT for Mexico is the same as that of U.S. south zone (Zone 2).

The Designer may specify a different MDMT based on sound engineering judgment in consultation with the Company's Materials Engineering department.

Table 1-1: Standard Minimum Design Temperature by Region

Country	Zone	Standard MDMT: Belowground piping	Standard MDMT: Components and Aboveground piping
Canada	-	-5°C (+23°F)	-45°C (-50°F)
US	Zone 1	-5°C (+23°F)	-45°C (-50°F)
	Zone 2	0°C (+32°F)	-29°C (-20°F)
Mexico	-	0°C (+32°F)	-29°C (-20°F)

1.3 Fracture Toughness Requirements

Fracture control is achieved by using materials with demonstrated Charpy V-Notch (CVN) absorbed energy at or below the MDMT. The minimum absorbed energies shall be as per the applicable materials specification or industry standard.

- **Note:** Pressure containing components NPS 4 and larger, with an MDMT other than -45°C (-50°F) (e.g., Zone 2 or site specific design), may actually be tested at -45°C (-50°F) as this is the required standard impact test temperature in most industry materials standards.

For the U.S. and Mexico, pipe and components equal or larger than NPS 4 with proven fracture toughness (demonstrated by CVN absorbed energy) are preferred for use in gas and liquids pipeline systems to enhance safe operation or to facilitate redeployment of materials to other projects.

Requirements are outlined below in Table 1-2 for liquid systems and Table 1-3 for gas systems.

Table 1-2: Fracture Toughness Requirements for Liquid Systems

Part	Size	Requirements	
		Canada	U.S. and Mexico[1]
Components	< NPS 4	Not required.	Not required.
	≥ NPS 4 and < NPS 16	Proven fracture toughness required.	• In Zone 1, proven fracture toughness is required. • In Zone 2, component materials without proven notch toughness are permissible where allowed by industry codes or standards.
	≥ NPS 16	Proven fracture toughness required.	Proven fracture toughness required.
Pipe	All	To facilitate use for other projects if necessary, consideration should be given to procuring pipe with a shear area requirement as determined through drop weight tear testing (for pipe > NPS 18) or Charpy V-notch testing (for pipe ≤ NPS 18) in accordance with the requirements CSA Z245.1, Category II requirements (Canada) or API 5L (U.S. and Mexico).	
	< NPS 4	Not required.	Not required.
	≥ NPS 4	Proven fracture toughness required.	Proven notch toughness at or below the MDMT is required for all carbon steel pressure containing pipe with a nominal size of NPS 16 and larger or when designed to be operated at a hoop stress of more than 20% SMYS (specified minimum yield strength) at the lower of 32°F or the MDMT as per ASME B31.4 paragraph 423.2.3.

Notes:

[1] Proven notch toughness is not mandatory for low-pressure facilities as defined in Section 1.1 of this Standard.

Table 1-3: Fracture Toughness Requirements for Gas Systems

Part	Size	Requirements	
		Canada	U.S. and Mexico
Components	< NPS 4	Not required.	Not required.
	≥ NPS 4 and < NPS 16	Proven fracture toughness is required.	Unless otherwise approved by Materials Engineering, proven fracture toughness is required for components when the MDMT is below -20°F (-29°C).
	≥ NPS 16	Proven fracture toughness is required.	Proven fracture toughness is required.
Pipe	< NPS 4	Not required.	Not required if it is designed to operate at hoop stress below 72% of SMYS
	≥ NPS 4 and ≤ NPS 18	For continuous piping runs[1] 100m (330 ft) or longer, demonstrated shear area from CVN testing at or below the MDMT is required.	
		Proven fracture toughness is required.	Proven fracture toughness is required if: • Pipeline is designed to operate at hoop stress over 72% of SMYS, or • Pipes are designed with MDMT below -20°F (-29°C), or • Pipe has a nominal size of NPS 16 and larger.
	> NPS 18	For continuous piping runs[1] 100m (330 ft) or longer, demonstrated shear area from drop-weight tear testing (DWTT) at or below the MDMT is required.	
		Proven fracture toughness is required.	Proven fracture toughness is required.

Notes:

[1] Defined as continuous pipe sections where the pipe has the same nominal wall thickness and there are no components.

1.4 Heat Treatment Requirements

The requirements in Table 1-4 apply to verification of heat treatment for carbon steel components for all jurisdictions.

Table 1-4: Heat Treatment Verification Requirements

Specified Minimum Yield Strength	Requirements
< 359 MPa (52 ksi)	No heat treatment verification is required.
≥ 359 MPa (52 ksi)	Materials Engineering shall verify compliance with the heat treatment procedures and controls of the applicable materials specification or industry standard. **Exception:** No resubmission of heat treatment procedures is necessary for manufacturers approved by Materials Engineering because the review and approval of these procedures are addressed during the qualification process.

1.5 Manufacturer Welding Requirements

All pressure containing welds and repair welds made by a manufacturer shall be performed using welders and welding procedures qualified in accordance with the applicable materials specification or industry standard. If no requirements exist, the procedures shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX or equivalent approved by the Company's Materials Engineering department.

Manufacturer welding procedure qualifications shall include CVN impact testing for the weld and heat affected zone (HAZ) as per the requirements of the applicable materials specification or industry standard. If no requirements exist, the CVN testing shall be done in accordance with Paragraphs UG-84 (g) and UG-84(h)(3) of ASME Boiler Pressure Vessel Code, Section VIII, Division 1.

1.6 Manufacturer NDE Requirements (items manufactured to Company specifications)

All pressure containing welds shall be examined using non-destructive examination (NDE) methods as per the applicable materials specification or industry standard. Critical sections in castings shall be examined using radiographic or ultrasonic methods in accordance with ASME Boiler and Pressure Vessel Code, Sec. V, Article 2 and Article 5, respectively. Welding ends of items shall be examined using liquid penetrant or magnetic particle methods in accordance with ASME Boiler and Pressure Vessel Code, Sec. V, Article 6 and 7, respectively.

2 MATERIALS REQUIREMENTS

Considering the factors addressed in Clauses 1.1 to 1.6, the Designer shall determine equipment-specific materials requirements based on the materials specifications and industry standards for piping and components listed in APPENDIX A and APPENDIX B. All materials covered in APPENDIX A and APPENDIX B shall be purchased from Approved Manufacturers (refer to Supply Chain department).

- TransCanada's proprietary material specifications shall be used where they are listed in APPENDIX A and APPENDIX B and where the Company is able to source the materials directly from a manufacturer.
- Where it is not possible to source the materials directly from a manufacturer, due to order size or availability of material, materials may be sourced from recognized/authorized distributors provided that:
    - The materials are from approved manufacturers, and
    - Applicable industry standards and Company technical requirements are met.

Materials Engineering shall be consulted to ensure technical requirements are met in this case.

- Piping and components not listed in APPENDIX A and APPENDIX B shall be ordered to the applicable industry standards and do not need to be sourced from approved manufacturers.

2.1 Additional Guidance Documentation

The Designer should consult the following documents for details concerning materials selection and design:

- TEG-MDC-L (Canada, Liquids)
- TEG-MDC-G (Canada, Gas)
- TEG-MDU-L (US/Mexico, Liquids)
- TEG-MDU-G (US/Mexico, Gas)

The tables included in these documents are considered to be guidance. The Designer may select other materials than those listed in the supporting documents as long as the requirements of this standard are met.

It should also be noted that the materials listed in these documents are preferred or considered to be the most common but other equivalent materials may also be available (e.g. ASTM A105 in lieu of A234 WPB). Some listings reference the forged product specifications and the comparable casting product specifications (e.g. ASTM A216 WCB in lieu of A105 or A352 LCB in lieu of A350 LF2) would also be suitable. In addition, more stringent requirements may be applied at the discretion of the project.

2.2 Deviations from Requirements

Unique circumstances (i.e. outside of standard design conditions) may require the development of materials engineering requirements that are outside of the requirements of this standard. Consideration shall be given on a case-by-case basis for deviation from the requirements of this standard and will require Materials Engineering approval either through a project specific agreement or through the variance process (see Section 4). Deviations to TransCanada requirements may be accepted, but deviations from the requirements of the applicable regulations and industry standards are not acceptable.

3 COMPLETE TEST REPORTS AND TRACEABILITY

The following reports and traceability requirements must be met:

- NPS 2 or larger: Material Test Report
- Smaller than NPS 2: Material Test Report or Certificate of Compliance

All materials used shall be traceable to certified material test reports or certificates of compliance in accordance with the identification or marking requirements in the applicable materials specification.

4 VARIANCES

Any deviation must follow the appropriate TransCanada Management of Change (MOC) Variance Procedure (EDMS No. 7728702).

5 GLOSSARY

Terms and definitions related to this Specification can be found in APPENDIX D.

6 REFERENCES

This document relies on a number of references to legislation (act, statutes, and regulations), certificates, and orders and may include directives, guidelines, standards, and codes to the extent they contain legally binding requirements for TransCanada.

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 6-1 and

Table 6-2.

Table 6-1: External References by Topic

Document No.	Title	Applicability
Legal Requirements		
NEB OPR SOR/99-294	National Energy Board Onshore Pipeline Regulations	Canada, Natural gas and sweet liquid hydrocarbon pipelines and pipeline facilities
Various	Applicable Provincial Regulations for Provincially Regulated Systems	Canada, Natural gas and sweet liquid hydrocarbon pipelines and pipeline facilities
Code of Federal Regulations, Title 49 Part 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards	US, Natural gas pipelines and pipeline facilities
Code of Federal Regulations, Title 49 Part 195	Transportation of Hazardous Liquids by Pipeline	US, Sweet liquid hydrocarbon pipelines and pipeline facilities
NOM-007-SECRE-2010	Transport of Natural Gas (Transporte de Gas Natural)	Mexico, Natural gas and sweet liquid hydrocarbon pipelines and pipeline facilities
Industry Codes and Standards		
CSA Z662	Canadian Standards Association, Oil and Gas Pipeline Systems	Canada, Natural gas and sweet liquid hydrocarbon pipelines and pipeline facilities

Document No.	Title	Applicability
ASME B31.3	American Society of Mechanical Engineers (ASME), Process Piping	When required, Canada, US and Mexico, facilities
ASME B31.4	American Society of Mechanical Engineers (ASME), Pipeline Transportation Systems for Liquids and Slurries	US and Mexico, Sweet liquid hydrocarbon pipelines and pipeline facilities
ASME B31.8	American Society of Mechanical Engineers (ASME), Gas Transmission and Distribution Piping Systems	US and Mexico, Natural gas pipelines and pipeline facilities

Table 6-2: External and Internal References (General)

Document No.	Title
Industry Codes and Standards	
CSA Z245.1	Steel Pipe
CSA Z245.11	Steel Fittings
CSA Z245.12	Steel Flanges
CSA Z245.15	Steel Valves
API 5L	Specification for Line Pipe
API 6D	Specification for Pipeline Valves
API 609	Butterfly Valves: Double-flanged, Lug- and Wafer-type
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.9	Factory-Made Wrought Buttwelding Fittings
ASME B16.11	Forged Fittings Socket Welding and Threaded
ASME B16.20	Metallic Gaskets for Pipe Flanges, Ring-Joint Spiral Wound and Jacketed
ASME B16.21	Nonmetallic Flat Gaskets for Pipes Flanges
ASME B16.25	Buttwelding Ends
ASME B16.34	Valves – Flanged, Threaded, and Welding End
ASME B16.47	Large Diameter Steel Flanges
ASME B16.49	Factory-Made, Wrought Steel, Buttwelding Induction Bends for Transportation and Distribution Systems
ASME BPVC-V	Boiler and Pressure Vessel Code, Section V, Nondestructive Examination

Document No.	Title
MSS SP-44	Steel Pipeline Flanges
MSS SP-75	Specification for High-Test, Wrought, Butt-Welding Fittings
MSS SP-83	Class 3000 Steel Pipe Unions, Socket Welding and Threaded
MSS SP-95	Swage Nipples and Bull Plugs
MSS SP-97	Integrally Reinforced Forged Branch Outlet Fittings - Socket Welding, Threaded and Buttwelding Ends
Internal References – Documents Referenced by this Standard	
EDMS No. 8194414	TES-FITG-B1 Induction Bends Specification (CDN-US-MEX)
EDMS No. 4424021	TES-FITG-CIF Specification for Contoured Insert Fittings (CDN-US-MEX)
EDMS No. 3779256	TES-FITG-EC1 End Closures Specification (CDN-US-MEX)
EDMS No. 3671270	TES-FITG-LD Carbon Steel Buttwelding Fittings Specification (CDN-US-MEX)
EDMS No. 3779258	TES-FITG-SAD Full Encirclement Reinforcing Saddles Specification (CDN-US-MEX)
EDMS No. 3671966	TES-FLGE-LD Carbon Steel Buttwelding Flanges Specification
EDMS No. 4423389	TES-FLGE-LD-US High Yield Carbon Steel Buttwelding Flanges Specification
EDMS No. 3670788	TES-PIPE-EW Electric Welded Pipe Specification (CDN-US-MEX)
EDMS No. 3776714	TES-PIPE-SAW Double Submerged Arc Welded Pipe Specification (CDN-US-MEX)
EDMS No. 1001891682	TES-VALV-G Steel Valves For Gas Services Specification (CDN-US-MEX)
EDMS No. 1001895584	TES-VALV-L Steel Valves for Liquid Service Specification (CDN-US-MEX)
EDMS No. 1001895758	TES-VALV-TOV Triple Offset Valves Specification (CDN-US-MEX)

7 DOCUMENT HISTORY

Rev.		
00	**Description**	**Effective Date**
	New document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	**Responsible Engineer**
	This document was developed in order to address the following requirements: • Provide a standard for the determination of Materials requirements.	Cindy Guan, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This standard was created to streamline the documentation required for the Materials group and to make it more easily accessible to those using the underlying specifications.	Cindy Guan, P. Eng.

8 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A.
Industry Standards	
N/A	N/A.
General	
N/A	This Standard is a new document.

9 APPROVALS

APPROVALS		
Originator: Derek Chen, P. Eng. Welding and Materials Engineering	Signature	Nov 1, 2016 Date
Reviewer: Sajjad Kazi, P. E. Welding and Materials Engineering	Signature	Nov 1, 2016 Date
Responsible Engineer: Cindy Guan, P. Eng., Welding and Materials Engineering	Signature Nov. 1, 2016 Date	PROFESSIONAL ENGINEER XINGSHENG (CINDY) GUAN ALBERTA APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, Manager Engineering Technical Governance	Signature	Nov. 1, 2016 Date

APPENDIX A CANADIAN MATERIALS REQUIREMENTS FOR LIQUID AND GAS SYSTEMS

Appendix Table A-1: Canadian Materials Requirements for Liquids and Gas Systems

Commodity	Size	Materials Specification	Industry Standards	Limitations
Pipe	≥ NPS 16	TES-PIPE-SAW TES-PIPE-EW	CSA Z245.1, Category II; or API 5L PSL 2	• Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests. • Above ground pipe should be sourced through integrity or station pipe orders directly from pipe mills. Pipe with Drop Weight Tear Testing (DWTT) below -18°C is very difficult to source from distributors.
	≥ NPS 10 and < NPS 16	TES-PIPE-EW	CSA Z245.1, Category II; or API 5L PSL 2; or ASTM A333 Gr. 6	
	≥ NPS 4 and < NPS 10	N/A		
Valves (Ball, Gate, Check, and Plug)	≥ NPS 16	TES-VALV-G (Gas) TES-VALV-L (Liquids)	CSA Z245.15, Category II; or API 6D	• Impact testing requirements per Section 1.3 to be applied for materials that do not include CVN tests. • At time of purchase it should be noted that, unless otherwise specified by the purchaser, Non-destructive testing (NDT) (RT/UT) for pressure containing welds or castings is not mandatory per CSA Z245.15. Both CVN testing at or above -29°C MDMT and NDTare not mandatory per API 6D.
	≥ NPS 4 and < NPS 16	N/A	CSA Z245.15, Category II; or API 6D	
Triple Offset Valves (Liquids Only)	≥ NPS 6	TES-VALV-TOV	API 609	N/A
Fittings	≥ NPS 16	TES-FITG-LD	CSA Z245.11; or MSS-SP-75	• Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests. • At time of purchase, it should be considered that per MSS SP-75, CVN testing is required at +20°F for NPS 16 or larger or grade WPHY 65 or greater only unless otherwise specified by the purchaser
	≥ NPS 4 and < NPS 16	N/A	CSA Z245.11; or MSS-SP-75; or ASME B16.9; or ASTM A420 WPL6	

Commodity	Size	Materials Specification	Industry Standards	Limitations
Flanges	≥ NPS 16	TES-FLGE-LD	CSA Z245.12; or ASME B16.5; or ASME B16.47 Series A	• Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests. • ASME B16.5 is only applicable up to NPS 24 and ASME B16.47 is only applicable above NPS 24. • Should it be necessary to use ASME flanges, Clause 4.3.12.5 of CSA Z662 requires that the pressure-temperature ratings in accordance with the applicable manufacturing standard shall apply (e.g.,. de-rating at 38°C and higher).
	≥ NPS 4 and < NPS 16	N/A	CSA Z245.12; or ASME B16.5	
Blind Flanges	≥ NPS 16	N/A	CSA Z245.12 or ASME B16.5 or ASME B16.47 Series A	
	≥ NPS 4 and < NPS 16	N/A	CSA Z245.12 or ASME B16.5 (Material ASTM A105)	
Induction Bends	All Sizes	TES-FITG-B1	ASME 16.49	N/A
Contoured Insert Fittings	All Sizes	TES-FITG-CIF	N/A	N/A
End Closures	All Sizes	TES-FITG-EC1	N/A	N/A
Saddles	All Sizes	TES-FITG-SAD	N/A	N/A
Pressure Vessels	All Sizes	N/A*	ASME BPVC Section VIII Division I	N/A

*TransCanada engineering specification(s) from other disciplines than Materials may apply.

APPENDIX B US AND MEXICO MATERIALS REQUIREMENTS FOR LIQUIDS AND GAS SYSTEMS

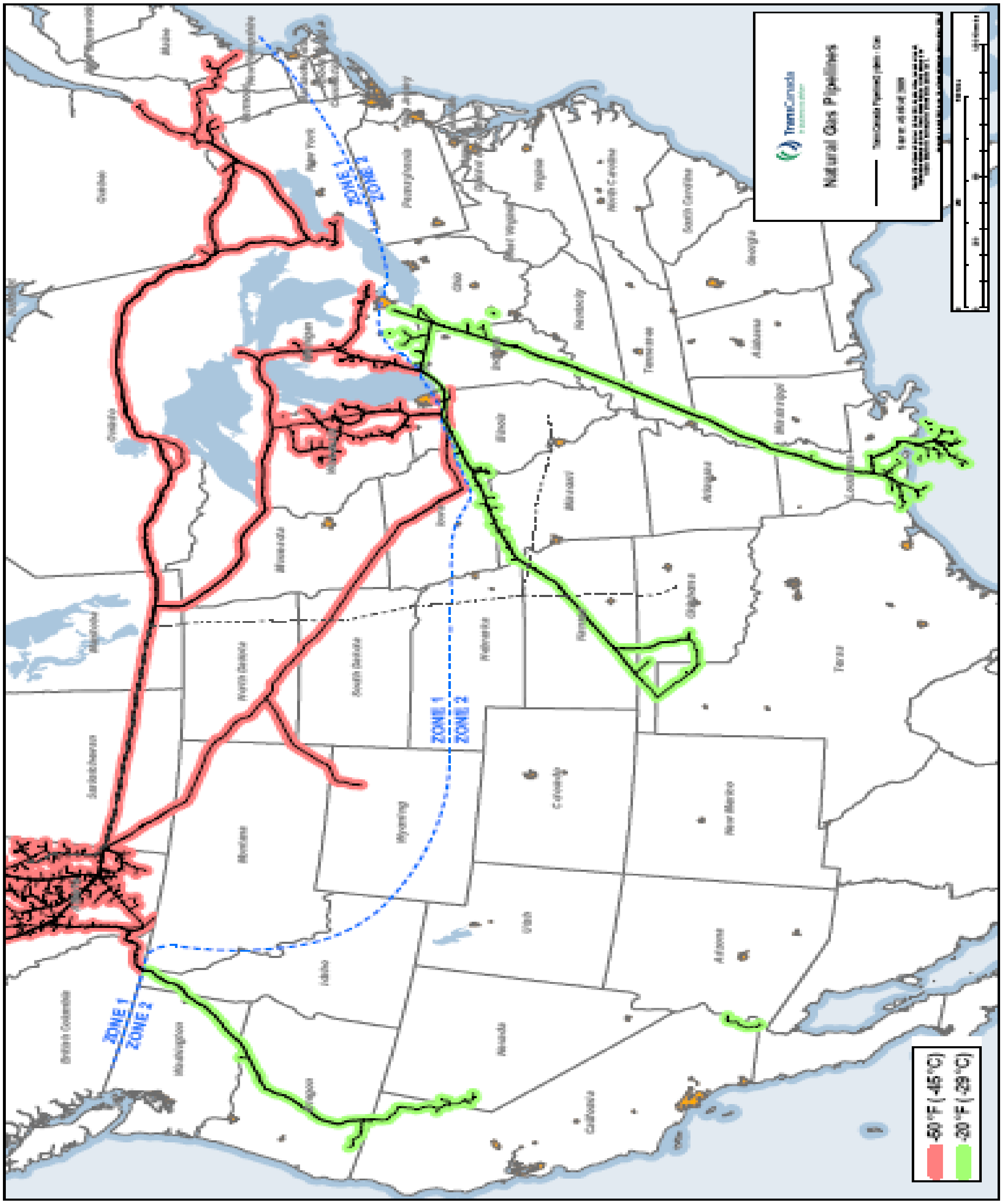
Appendix Table B-1: US and Mexico Materials Requirements for Liquids and Gas Systems

Commodity	Size	Materials Specification	Industry Standards		Limitations
			Zone 1 (-50°F or < -20°F MDMT)	Zone 2 or Below ground (-20°F or +32°F MDMT)	
Pipe	≥ NPS 16	TES-PIPE-SAW TES-PIPE-EW	API 5L PSL 2	API 5L PSL 2	• Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests. • Above ground pipe for areas with MDMT less than -20°F should be sourced through integrity or station pipe orders directly from pipe mills as pipe with CVN and DWTT below this temperature is difficult to source from distributors.
	≥ NPS 10 and < NPS 16	TES-PIPE-EW	ASTM A333 or API 5L PSL 2	ASTM A106 Gr. B or API 5L PSL 2	
	≥ NPS 4 and < NPS 10	N/A	ASTM A333 or API 5L PSL 2	ASTM A106 Gr. B or API 5L PSL 2	
Valves (Ball, Gate, Check, and Plug)	≥ NPS 16	TES-VALV-G (Gas) TES-VALV-L (Liquids)	API 6D	API 6D	• Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests. • At time of purchase it should be considered that CVN testing at or above -20°F MDMT and NDT (RT/UT) for pressure containing welds or castings are not required per API 6D unless otherwise specified by the purchaser.
	≥ NPS 4 and < NPS 16	N/A	API 6D	API 6D	
Triple Offset Valves (Liquids Only)	≥ NPS 4	TES-VALV-TOV	API 609	API 609	N/A
Fittings	≥ NPS 16	TES-FITG-LD	MSS SP-75	MSS SP-75	• Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests. • At time of purchase, it should
	≥ NPS 4 and < NPS 16	N/A	MSS SP-75 or ASME B16.9 (Material ASTM A420 WPL6)	MSS SP-75 or ASME B16.9 (Material ASTM A234 WPB)	

Commodity	Size	Materials Specification	Industry Standards		Limitations
			Zone 1 (-50°F or < -20°F MDMT)	Zone 2 or Below ground (-20°F or +32°F MDMT)	
					be considered that per MSS SP-75, CVN testing is required at +20°F for NPS 16 or larger or grade WPHY 65 or higher only unless otherwise specified by the purchaser.
Flanges	≥ NPS 16	TES-FLGE-LD-US	MSS-SP-44; and ASME B16.5 or B16.47 Series A	MSS-SP-44; and ASME B16.5 or B16.47 Series A	• Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests. • ASME B16.5 is applicable up to NPS 24 and B16.47 is applicable above NPS 24 only and maximum operating pressure for ASME flanges are based on a maximum temperature of 100°F. • Maximum operating pressures for MSS flanges are based on a maximum operating temperature of 250°F
	≥ NPS 4 and < NPS 16	N/A	MSS SP-44 or ASME B16.5 (Material ASTM A350 LF2)	MSS SP-44 or ASME B16.5 (Material ASTM A105)	
Blind Flanges	All Sizes	N/A	MSS SP-44, ASME B16.5 or ASME B16.47 Series A		
Induction Bends	All Sizes	TES-FITG-B1	ASME 16.49		N/A
Contoured Insert Fittings	All Sizes	TES-FITG-CIF	N/A		N/A
End Closures	All Sizes	TES-FITG-EC1	N/A		N/A
Saddles	All Sizes	TES-FITG-SAD	N/A		N/A
Pressure Vessels	All Sizes	N/A*	ASME BPVC Section VIII Division I		N/A

*TransCanada engineering specification(s) from other disciplines than Materials may apply.

APPENDIX C TEMPERATURE ZONE MAP



APPENDIX D TERMS AND DEFINITIONS

Terms	Definitions
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Material
CFR	Code of Federal Regulations
CSA	Canadian Standards Association
DOT	United States Department of Transportation
ISO	International Organization for Standardization
MSS	Manufacturers Standardization Society
NEB	National Energy Board
NOM	Norma Oficial Mexicana
Regulatory Authority	The national and/or local regulator having jurisdiction over the facility.
Welding Procedure	The Welding Procedure Specification, Procedure Qualification Record, and all associated non-destructive and destructive test data