RFB NO. 318047

CONSTRUCTION DOCUMENTS
PROJECT MANUAL

DANE COUNTY DEPARTMENT OF PUBLIC WORKS,
HIGHWAY AND TRANSPORTATION

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

REQUEST FOR BIDS NO. 318047
HVAC EQUIPMENT REPLACEMENT
VERONA AREA NEEDS NETWORK
1200 EAST VERONA AVENUE
VERONA, WISCONSIN

Due Date / Time: **TUESDAY, MAY 14, 2019 / 2:00 P.M.**

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:

TODD DRAPER, PROJECT MANAGER
TELEPHONE NO.: 608/267-0119
FAX NO.: 608/267-1533
E-MAIL: DRAPER@COUNTYOFDANE.COM

SEALS PAGE

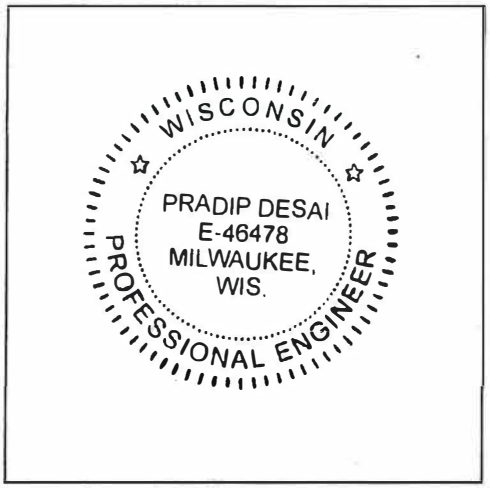
BID NO. 318047
PROJECT: HVAC EQUIPMENT REPLACEMENT
VERONA AREA NEEDS NETWORK

MECHANICAL ENGINEER
I hereby certify that this drawing, specification or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Wisconsin.

Dated: April 9, 2019

Matthew L. Heil - Registration No. E-36013
Exp. 7/31/2020

ELECTRICAL ENGINEER
I hereby certify that this drawing, specification or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Wisconsin.



Dated: April 9, 2019

Pradip P. Desai - Registration No. 46478-6
EXPIRATION: 7/3/2020

TABLE OF CONTENTS FOR RFB NO. 318047

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS

Project Manual Cover Page
Seals Page
Table of Contents
Advertisement for Bids (Legal Notice)
Best Value Contracting Application
Instructions to Bidders
Bid Form
Fair Labor Practices Certification
Sample Public Works Construction Contract
Sample Bid Bond
Sample Performance Bond
Sample Payment Bond
General Conditions of Contract
Supplementary Conditions

DIVISION 01 - GENERAL REQUIREMENTS

01 00 00 - Basic Requirements
01 74 19 - Construction Waste Management, Disposal & Recycling

DIVISION 23 - HEATING, VENTILATING AND AIR CONDITIONING (HVAC)

23 05 00 - Common Work Results for HVAC
23 05 14 - Variable Frequency Drives
23 05 15 - Piping Specialties
23 05 23 - General Duty Valves for HVAC Piping
23 05 29 - Hangers and Supports for HVAC Piping and Equipment
23 05 93 - Testing, Adjusting and Balancing for HVAC
23 07 00 - HVAC Insulation
23 09 14 - Pneumatic and Electric Instrumentation and Control Devices for HVAC
23 09 93 - Sequence of Operations for HVAC Controls
23 21 13 - Hydronic Piping
23 31 00 - HVAC Ducts and Casings
23 33 00 - Air Duct Accessories
23 36 00 - Air Terminal Units
23 37 13 - Diffusers, Registers and Grilles
23 41 00 - Particulate Air Filtration
23 74 13 - Roof Top Air Handling Units
23 82 00 - Heating and Cooling Terminal Units

DIVISION 26 - ELECTRICAL (NOT A PART OF THIS BID)

26 05 00 - Common Work Results for Electrical
26 05 04 - Cleaning Inspection and Testing of Electrical
26 05 19 - Low-Voltage Electrical Power Conductors and Cables
26 05 23 - Control Voltage Electrical Power Cables
26 05 26 - Grounding and Bonding for Electrical Systems
26 05 29 - Hangers and Supports for Electrical Systems
26 05 33 - Raceway and Boxes for Electrical Systems
26 05 53 - Identification for Electrical Systems
26 24 16 - Panelboards
26 27 02 - Equipment Wiring Systems

26 27 26 - Wiring Devices
26 27 28 - Disconnect Switches
26 28 13 - Fuses
26 29 00 - Low-Voltage Controllers
26 43 13 - Surge Protective Device for Low-Voltage Electrical Power Circuit

DRAWINGS

Plot drawings on 24” x 36” (ARCH D) paper for correct scale or size.

T000 - Title Sheet
M000 - General Notes, Symbols and Abbreviation
M100 - First Floor Plan - Demolition - Ductwork
M101 - First Floor Plan - Demolition - Piping
M102 - Roof Plan - Demolition - Mechanical
M200 - First Floor Plan - New - Ductwork
M201 - First Floor Plan - New - Piping
M202 - Roof Plan - New - Mechanical
M300 - Mechanical Schedules
M400 - Mechanical Details
M401 - Mechanical Details
M500 - HVAC Sequences
E100 - First Floor - Electrical Demolition Plan
E200 - First Floor - Electrical Plan
E300 - Electrical One-Line Diagram
E400 - Electrical Schedules

LEGAL NOTICE

INVITATION TO BID

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

2:00 P.M., TUESDAY, MAY 14, 2019

RFB NO. 318047

HVAC EQUIPMENT REPLACEMENT

VERONA AREA NEEDS NETWORK

1200 E. VERONA AVE., VERONA, WI

Dane County is inviting Bids for construction services to replace HVAC equipment & upgrade the facility electrical service. Only firms with capabilities, experience & expertise with similar projects should obtain this Request for Bids (RFB) document & submit Bids.

RFB document may be obtained after **2:00 p.m. on April 16, 2019** by downloading it from bids-pwht.countyofdane.com. Please call Todd Draper, Project Manager, at 608/267-0119, or our office at 608/266-4018, for any questions or additional information.

All Bidders must be pre-qualified as a Best Value Contractor before award of Contract. Complete Pre-qualification Application for Contractors at countyofdane.com/pwht/BVC_Application.aspx or obtain one by calling 608/267-0119.

A pre-bid facility tour will be held May 1, 2019 at 10:00 a.m. at the Verona Area Needs Network, starting in the building lobby. Bidders are strongly encouraged to attend this tour.

PUBLISH: **APRIL 18 & APRIL 23, 2019 - WISCONSIN STATE JOURNAL**

APRIL 18 & APRIL 23, 2019 - THE DAILY REPORTER

Department of Public Works, Highway & Transportation
Public Works Engineering Division
608/266-4018

Gerald J. Mandli, P.E.
Commissioner / Director

Joseph T. Parisi
County Executive

Deputy Director
Todd Draper

1919 Alliant Energy Center Way
Madison, Wisconsin 53713
Fax: 608/267-1533
www.countyofdane.com/pwht/public_works.aspx

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 pre-certified 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 Todd Draper 608-267-0119).	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: _____

(Application is invalid without signature)

Print Name: _____ Date: _____

Title: _____

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

REMEMBER!

RETURN ALL TO FORMS AND ATTACHMENTS, OR QUESTIONS TO:

TODD DRAPER
EMAIL: DRAPER@COUNTYOFDANE.COM
OFFICE: (608)267-0119, 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

TABLE OF CONTENTS

1. GENERAL 1
2. DRAWINGS AND SPECIFICATIONS 1
3. INTERPRETATION 2
4. QUALIFICATIONS OF BIDDER (CONTRACTOR AND SUBCONTRACTOR) 2
5. BID GUARANTEE 3
6. WITHDRAWAL OF BIDS 3
7. CONTRACT FORM 3
8. CONTRACT INTERESTS BY COUNTY PUBLIC OFFICIALS 3
9. EMERGING SMALL BUSINESS PROVISIONS 4
10. METHOD OF AWARD - RESERVATIONS 6
11. SECURITY FOR PERFORMANCE AND PAYMENTS 6
12. TAXES 6
13. SUBMISSION OF BIDS 7
14. SUBCONTRACTOR LISTING 7
15. ALTERNATE BIDS 8
16. INFORMATIONAL BIDS 8
17. UNIT PRICES 8
18. COMMENCEMENT AND COMPLETION 8
19. WORK BY OWNER 8
20. SPECIAL HAZARDS COVERAGE 8
FORM A 9
FORM B 10
FORM C 11
FORM D 12

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. Note: all Division 26 work is being provided by others.

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 May 1, 2019 at 10:00 a.m. at the Verona Area Needs Network, 1200 East Verona Avenue, Verona, WI, starting the building lobby. Attendance by all bidders is optional, however bidders and subcontractors are strongly encouraged to attend.

D. 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 past projects. 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. This work will be accomplished by Owner or will be let under separate contracts and will not be included under this Contract:

1. Provide temporary spot cooling for facility until the Work's completion.

2. All electrical work. Contractor shall work with County-provided electrician.

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
(Copy this Form as necessary to provide complete information)
EMERGING SMALL BUSINESS REPORT - INVOLVEMENT

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

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

Page Intentionally Left Blank

Name of Bidding Firm: _____

BID FORM

BID NO. 318047
PROJECT: HVAC EQUIPMENT REPLACEMENT
VERONA AREA NEEDS NETWORK

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 replace HVAC equipment and upgrade the facility electrical service. Note: all Division 26 work is being provided by others. 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

The undersigned agrees to add the alternate(s) portion of the Work as described, for the following addition(s) to or subtraction(s) from the Base Bid, as stipulated below.

ALTERNATE BID 1 - LUMP SUM:
Add price for providing additional VAV controls. as noted in the Drawings & 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 Department of Administration must have this project completed by September 27, 2019. Assuming this Work can be started by June 18, 2019, 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 _____.

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 agrees to be qualified as a Best Value Contractor or will have proven their exemption before the award of this contract.

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: _____

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

DANE COUNTY BEST VALUE CONTRACTING PRE-QUALIFICATION

General Contractors & all Subcontractors must be pre-qualified as a Best Value Contractor with the Dane County Public Works Engineering Division before the award of contract. Qualification & listing is not permanent & must be renewed every 24 months. Obtain a *Best Value Contracting Application* by calling 608/266-4018 or complete one online at:

countyofdane.com/pwht/BVC_Application.aspx

DANE COUNTY VENDOR REGISTRATION PROGRAM

All bidders are strongly encouraged to be a registered vendor with Dane County. Registering allows vendors an opportunity to receive notifications for RFBs & RFPs issued by the County and provides the County with up-to-date company contact information. Complete a new form or renewal online at:

danepurchasing.com/Account/Login?

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 25.09 is as follows:

(1) 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 Controller 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.

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COUNTY OF DANE

PUBLIC WORKS CONSTRUCTION CONTRACT

Contract No. _____ Bid No. 318047

Authority: 2018 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 Deputy Public Works Director, 1919 Alliant Energy Center Way, Madison, WI 53713, desires to have CONTRACTOR provide HVAC Equipment Replacement at the Verona Area Needs Network [including Alternate Bid 1 (if applicable)] ("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 Tailored Engineering (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. 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

Sample

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.

4. 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.

5. 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".

6. 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.

7. 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.

8. 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.

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

Sample

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

Sample

AIA® Document A310™ – 2010

Bid Bond

CONTRACTOR:
(Name, legal status and address)

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

OWNER:
(Name, legal status and address)

BOND AMOUNT:

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

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.

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

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

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AIA® Document A312™ – 2010

Performance 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 16

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

Sample

§ 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.

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§ 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:

Sample

(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)

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		**SURETY**	
Company:	*(Corporate Seal)*	Company:	*(Corporate Seal)*
Signature:		Signature:	
Name and Title:	Name	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:)

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.

Sample

§ 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:

Sample

(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.

GENERAL CONDITIONS OF CONTRACT

TABLE OF CONTENTS

1. CONSTRUCTION DOCUMENTS 2
2. DEFINITIONS 2
3. ADDITIONAL INSTRUCTIONS AND DRAWINGS 2
4. SHOP DRAWINGS, PRODUCT DATA AND SAMPLES 3
5. CUTTING AND PATCHING 4
6. CLEANING UP 4
7. USE OF SITE 4
8. MATERIALS AND WORKMANSHIP 5
9. CONTRACTOR'S TITLE TO MATERIALS 5
10. "OR EQUAL" CLAUSE 5
11. PATENTS AND ROYALTIES 6
12. SURVEYS, PERMITS, REGULATIONS AND TAXES 7
13. CONTRACTOR'S OBLIGATIONS AND SUPERINTENDENCE 7
14. WEATHER CONDITIONS 8
15. PROTECTION OF WORK AND PROPERTY 8
16. INSPECTION AND TESTING OF MATERIALS 8
17. REPORTS, RECORDS AND DATA 9
18. CHANGES IN THE WORK 9
19. EXTRAS 10
20. TIME FOR COMPLETION 10
21. CORRECTION OF WORK 10
22. SUBSURFACE CONDITIONS FOUND DIFFERENT 11
23. RIGHT OF DEPARTMENT TO TERMINATE CONTRACT 11
24. CONSTRUCTION SCHEDULE AND PERIODIC ESTIMATES 11
25. PAYMENTS TO CONTRACTOR 12
26. WITHHOLDING OF PAYMENTS 14
27. ACCEPTANCE OF FINAL PAYMENT AS RELEASE 14
28. PAYMENTS BY CONTRACTOR 14
29. CONTRACT SECURITY 15
30. ASSIGNMENTS 15
31. MUTUAL RESPONSIBILITY OF CONTRACTORS 15
32. SEPARATE CONTRACTS 15
33. SUBCONTRACTS 16
34. PUBLIC WORKS PROJECT MANAGER'S AUTHORITY 16
35. ARCHITECT / ENGINEER'S AUTHORITY 16
36. STATED ALLOWANCES 17
37. ESTIMATES OF QUANTITIES 17
38. LANDS AND RIGHTS-OF-WAY 17
39. GENERAL GUARANTEE 17
40. CONFLICTING CONDITIONS 18
41. NOTICE AND SERVICE THEREOF 18
42. PROTECTION OF LIVES AND HEALTH 18
43. AFFIRMATIVE ACTION PROVISION AND MINORITY / WOMEN / DISADVANTAGED BUSINESS ENTERPRISES 19
44. COMPLIANCE WITH FAIR LABOR STANDARDS 19
45. DOMESTIC PARTNERSHIP BENEFITS 20
46. USE AND OCCUPANCY PRIOR TO ACCEPTANCE 20
47. MINIMUM WAGES 20
48. CLAIMS 20
49. ANTITRUST AGREEMENT 20
50. INSURANCE 21
51. WISCONSIN LAW CONTROLLING 23

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.

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.

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. Not Used.

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. Not Used.

48. CLAIMS

A. No claim may be made until Department's Deputy 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.

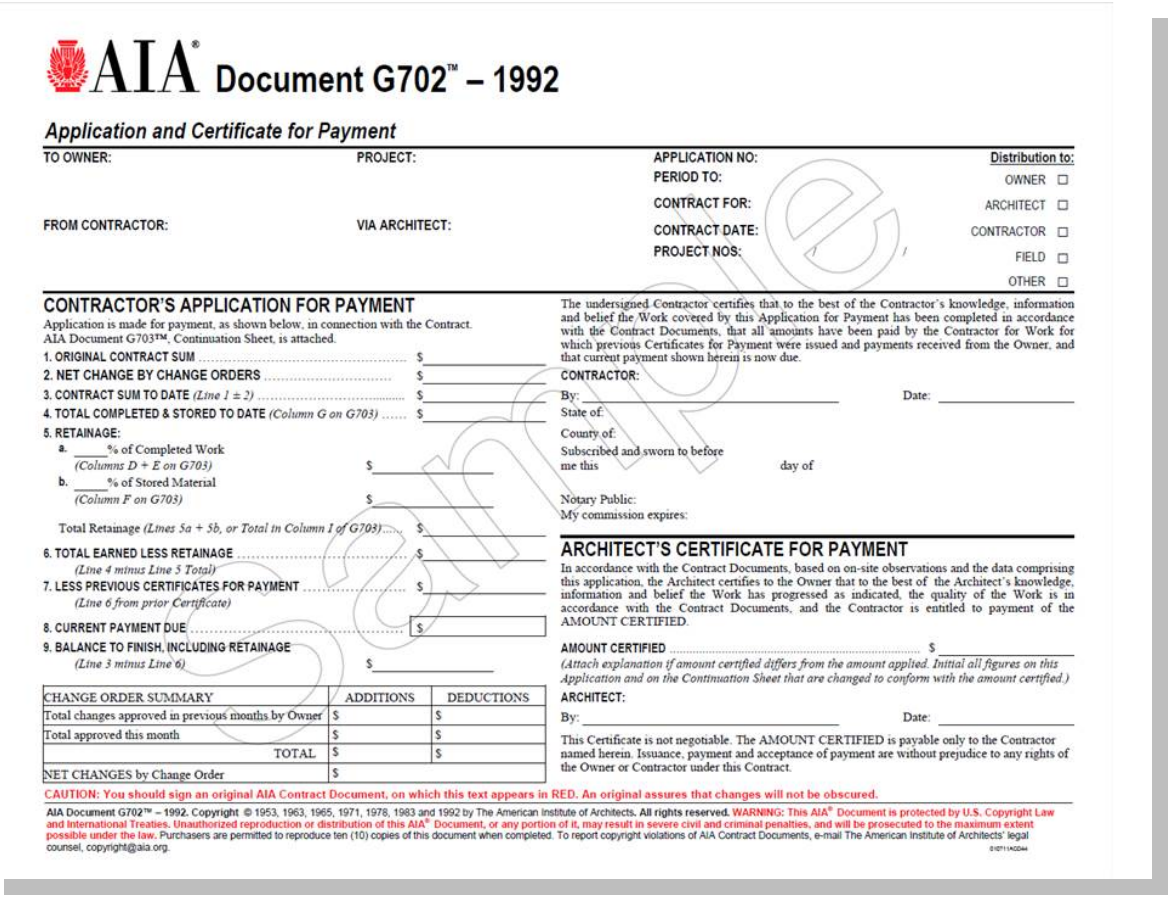
51. WISCONSIN LAW CONTROLLING

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 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.

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.

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Sample

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
ITEM NO.	DESCRIPTION OF WORK	SCHEDULED VALUE	WORK COMPLETED: FROM PREVIOUS APPLICATION (D + E)	WORK COMPLETED: 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								

Sample

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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. Coordination
8. Cutting and Patching
9. Conferences
10. Progress Meetings
11. Job Site Administration
12. Submittal Procedures
13. Proposed Products List
14. Shop Drawings
15. Product Data
16. Samples
17. Manufacturers' Instructions
18. Manufacturers' Certificates
19. Quality Assurance / Quality Control of Installation
20. References
21. Interior Enclosures
22. Protection of Installed Work
23. Parking
24. Staging Areas
25. Occupancy During Construction and Conduct of Work
26. Protection
27. Progress Cleaning
28. Products
29. Transportation, Handling, Storage and Protection
30. Product Options
31. Substitutions
32. Starting Systems
33. Demonstration and Instructions
34. Contract Closeout Procedures
35. Final Cleaning
36. Adjusting
37. Operation and Maintenance Data
38. Spare Parts and Maintenance Materials
39. 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 replacement HVAC equipment systems for this facility.

B. Work by Owner:
   1. Provide temporary spot cooling until the Work's completion.
   2. All electrical work. Contractor shall work with County-provided electrician.

C. Permits: Prior to commencement of the Work, Contractor to secure any and all necessary permits for completion of the Work and facility occupancy.

D. Diggers Hotline:
   1. It is General Contractor's responsibility to contact Diggers Hotline to have all utility locations marked prior to excavation and planning excavation 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. Contractor's costs for Products, delivery, installation, labor, insurance, payroll, taxes, bonding, equipment rental, overhead and profit will be included in Change Orders authorizing expenditure of funds from contingency allowance.

1.6 ALTERNATES

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

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

C. Schedule of Alternates:
   1. Additional VAV Controls.
      a. Detailed in Drawings & Specifications.

1.7 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. Construct work in stages to accommodate VANN operations. All activities shall be coordinated one (1) week (minimum) in advance with Public Works Project Manager unless noted otherwise in these specifications.

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

1.8 CUTTING AND PATCHING

A. Employ skilled and experienced installer to perform cutting and patching new work; restore work with new Products.

B. Submit written request in advance of cutting or altering structural or building enclosure elements.

C. Fit work tight to adjacent elements. Maintain integrity of wall, ceiling, or floor construction; completely seal voids.

D. Refinish surfaces to match adjacent finishes.

1.9 CONFERENCES

A. Project shall have pre-bid conference; see Instructions to Bidders.

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

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

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

1.10 PROGRESS MEETINGS

A. Schedule and administer meetings throughout progress of the Work at minimum of one (1) per week, with Public Works Project Manager.

B. 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.

1.11 JOB SITE ADMINISTRATION

A. Contractor shall have project superintendent on site minimum of two (2) hours per week during progress of the Work.

B. Architect / Engineer shall have representative on site minimum of two (2) hours per week on average during progress of the Work.

1.12 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.

1.13 PROPOSED PRODUCTS LIST

A. Within fifteen (10) 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.

1.14 SHOP DRAWINGS

A. Submit number of copies that Contractor requires, plus three (3) copies that shall be retained by Public Works Project Manager.

1.15 PRODUCT DATA

A. Submit number of copies that Contractor requires, plus two (2) copies that shall be retained by Public Works Project Manager.

B. Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturer's standard data to provide information unique to this Project.

1.16 SAMPLES

A. Submit samples to illustrate functional and aesthetic characteristics of Product.

B. Submit samples of finishes from full range of manufacturers' standard colors, textures, and patterns for Public Works Project Manager's selection.

1.17 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.

1.18 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.

1.19 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.

1.20 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.

1.21 INTERIOR ENCLOSURES

A. Provide temporary partitions as required to separate work areas from Owner occupied areas, to prevent distribution of dust and moisture into Owner occupied areas, and to prevent damage to existing materials and equipment.

1.22 PROTECTION OF INSTALLED WORK

A. Protect installed work and provide special protection where specified in individual Specification sections.

1.23 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.

1.24 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.

1.25 OCCUPANCY DURING CONSTRUCTION AND CONDUCT OF WORK

A. All construction material and salvage material shall be removed from facility or secured at day's end.

B. Contractors are asked to not work at facility if they are ill with something contagious.

C. Smoking is prohibited on Dane County property.

D. Owner reserves right at any time to dismiss from premises any Contractor or construction personnel that do not uphold requirements of this Section.

E. 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.

F. 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.

G. Work shall be done and temporary facilities furnished so as not to interfere with access to any occupied area and so as to cause least possible interference with normal operation of facility or any essential service thereof.

H. Contractor shall, at all times, provide approved, safe walkways and facility entrances for use by Owner, employees and public.

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

J. 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.

K. 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.

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

1.26 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.

C. Contractor shall provide and maintain guard lights at all barricades, railings, obstructions in streets, roads or sidewalks and at all trenches adjacent to public walks or roads.

1.27 PROGRESS CLEANING

A. Maintain areas free of waste materials, debris, and rubbish. Maintain site in clean and orderly condition.

1.28 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.

1.29 TRANSPORTATION, HANDLING, STORAGE AND PROTECTION

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

1.30 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 may be considered. Owner reserves right to approve or reject substitutions based on Specification requirements and intended use.

1.31 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.

1.32 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.

1.33 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.

1.34 CONTRACT CLOSEOUT PROCEDURES

A. Submit written certification that Construction Documents have been reviewed, the Work has been inspected, and the Work is complete in accordance with Construction Documents and ready for Public Works Project Manager's inspection.

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

1.35 FINAL CLEANING

A. Execute final cleaning prior to final inspection.

B. Clean interior and exterior surfaces exposed to view.

C. Remove waste and surplus materials, rubbish, and construction facilities from site.

1.36 ADJUSTING

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

1.37 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.

1.38 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.

1.39 AS-BUILT AND RECORD DRAWINGS AND SPECIFICATIONS

A. Contractor-produced Drawings and Specifications shall remain property of Contractor whether Project for which they are made is executed or not. Contractor shall furnish Architect / Engineer 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.

B. Architect / Engineer shall update original Construction Documents to include all Addendums & any other changes including those provided by Contractor in As-Built Drawings & Specifications. These updates are project Record Drawings & Specifications.

C. Architect / Engineer shall furnish Public Works Project Manager with Record Drawings as detailed in Professional Services Agreement.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

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. Cardboard.
   5. Metal.

B. These materials can be recycled elsewhere in Dane County area:
   1. Foam Insulation & Packaging (extruded and expanded).
   2. 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:_____
Cardboard	_____ cu. ft. _____ lbs.	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:_____
Metals	_____ cu. yds. _____ tons	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:_____
Foam Insulation	_____ cu. ft. _____ lbs.	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:_____
Barrels & Drums	_____ units	_____ Recycled _____ Reused _____ Landfilled _____ Other	Name:_____
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:_____

SECTION 23 05 00
COMMON WORK RESULTS FOR HVAC

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. Base Bid: It is the intent of these specifications to provide complete and workable mechanical systems as shown on the accompanying plans and as specified herein except such parts as are specifically exempted herein. Provide all necessary supervision, coordination, labor, materials, equipment, fixtures, dryage, hoisting, tools, transportation, plant services and facilities, machinery and connections to utilities for the installation of complete and operable mechanical systems. If details or special conditions are required in addition to those shown on drawings, provide all material and equipment usually furnished with such systems or required to complete their installation, whether noted in plans and specification or not. Reference front end specifications for breakout between the mechanical and electrical contractor scope of work.
   1. Note: all Division 26 (Electrical) work is being provided by others.

B. **Alternate Bid Pack #1**: Replace 14 VAV controllers, hot water control valves, and actuators with Distech devices tied to a Niagara N4 supervisory network controller.

C. Materials and labor shall be new (unless noted otherwise), first class and workmanlike and shall be subject at all times to the A/E's inspections, tests and approval from the commencement until the acceptance of the completed work.

D. The layout shown on the drawings is necessarily diagrammatic but shall be followed as closely as other work will permit. The drawings provide design intent. The Contractor shall verify all dimensions at the site and be responsible for their accuracy.

E. Because of the scale of the Drawings, certain basic items, such as, pipe fittings, duct fittings, access panels, and sleeves, may not be shown. Where such items are required by Code or by other Sections, or where required for proper installation of the Work, such items shall be included, whether shown or not.

F. In the event of any inconsistencies between the specifications, drawings, contract documents, applicable laws, statutes, ordinances, building codes, rules and regulations, the contractor shall provide the better quality or greater quantity of work and comply with or conform its work to the most stringent legal or contractual requirements.

G. Changes from these drawings required to make this work conform to the building construction shall be made only with prior written approval of the Architect/Engineer. All proposed changes shall be shown on shop drawings. All measurements shall be verified by actual observation and all work shall fit in place meeting the approval of the Architect/Engineer.

H. Equipment Specification may not deal individually with minute items required, such as, components, parts, controls, and devices which may be required to produce the equipment performance specified or as required to meet the equipment warranties. Where such items are required to make the system operational, they shall be included by the supplier of the equipment at no additional cost, whether or not specifically called for.

1.02 SECTION INCLUDES

A. This section includes information common to two or more technical specification sections or items that are of a general nature, not conveniently fitting into other technical sections.
   1. Submittals
   2. Reference Standards
   3. Quality Assurance
   4. Guarantee
   5. Work by Owner
   6. Equipment Furnished by Others
   7. Provisions for Future
   8. Operation and Maintenance Instructions
   9. Record Documents
   10. Continuity of Existing Services

11. Protection of Finished Surfaces
12. Sealing and Firestopping
13. Off Site Storage
14. Regulatory Requirements
15. Certificates and Inspections
16. Coordination
17. Demolition and Existing Requirements
18. Request and Certification for Payment
19. Sleeves and Openings
20. Omissions
21. Definitions
22. Project/Site Conditions
23. Work Sequence and Scheduling
24. Salvage Materials
25. Training
26. Access Panels and Doors
27. Identification
28. Demolition
29. Cutting and Patching
30. Lintels
31. Building Access
32. Equipment Access
33. Lubrication
34. Housekeeping and Clean Up

1.03 RELATED WORK

A. Applicable provisions of Division 1 govern work under this section.
B. This section applies to all Division 23 sections.

1.04 SUBMITTALS

A. Submit shop drawings for equipment under each section per requirements listed in that section, as well as per Division 1.
B. Submit for all equipment and systems as indicated in the respective specification sections, marking each submittal with that specification section number. Mark general catalog sheets and drawings to indicate specific items being submitted and proper identification of equipment by name and/or number, as indicated in the contract documents. Failure to do this may result in the submittal(s) being returned to the Contractor for correction and resubmission. Do not submit hard copies of web pages. Failing to follow these instructions does not relieve the Contractor from the requirement of meeting the project schedule.
C. On request from the A/E, the successful bidder shall furnish additional drawings, illustrations, catalog data, performance characteristics, etc.
D. Submittals shall be grouped to include complete submittals of related systems, products, and accessories in a single submittal. Mark dimensions and values in units to match those specified. Include wiring diagrams of electrically powered equipment.
E. The submittals must be approved before fabrication is authorized.
F. Provide electronic copies of all submittals for review.
G. Before submitting electrically powered equipment, verify that the electrical power and control requirements for the equipment are in agreement with the motor starter schedule on the electrical drawings. Include a statement on the shop drawing transmittal to the architect/engineer that the equipment submitted, and the motor starter schedule is in agreement or indicate any discrepancies. See related comments in Section 23 05 13 in Part 1 under Electrical Coordination.

1.05 REFERENCE STANDARDS

A. Abbreviations of standards organizations referenced in other sections are as follows:
   1. AABC Associated Air Balance Council
   2. ABMA American Boiler Manufacturers Association

3. ADC Air Diffusion Council
4. AGA American Gas Association
5. AMCA Air Movement and Control Association
6. ANSI American National Standards Institute
7. AHRI Air-Conditioning, Heating and Refrigeration Institute
8. ASHRAE American Society of Heating, Refrigerating and Air Conditioning Engineers
9. ASME American Society of Mechanical Engineers
10. ASTM American Society for Testing and Materials
11. AWWA American Water Works Association
12. AWS American Welding Society
13. CGA Compressed Gas Association
14. CTI Cooling Tower Institute
15. EJMA Expansion Joint Manufacturers Association
16. EPA Environmental Protection Agency
17. ETL Edison Testing Laboratories
18. FM Factory Mutual Insurance Company
19. GAMA Gas Appliance Manufacturers Association
20. HI Hydraulic Institute
21. ICC International Code Council
22. IEEE Institute of Electrical and Electronics Engineers
23. IRI Industrial Risk Insurers
24. ISA Instrument Society of America
25. ISO International Organization for Standardization
26. MCAA Mechanical Contractors Association of America
27. MICA Midwest Insulation Contractors Association
28. MSS Manufacturer's Standardization Society of the Valve & Fitting Industry, Inc.
29. NBS National Bureau of Standards
30. NEBB National Environmental Balancing Bureau
31. NEC National Electric Code
32. NEMA National Electrical Manufacturers Association
33. NFPA National Fire Protection Association
34. OSHA Occupational Safety and Health Administration
35. SMACNA Sheet Metal and Air Conditioning Contractors' National Association. Inc.
36. TABB Testing, Adjusting and Balancing Bureau
37. UL Underwriters Laboratories Inc.
38. ASTM E814 Standard Test Method for Fire Tests of Through-Penetration Fire Stops
39. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
40. UL1479 Fire Tests of Through-Penetration Firestops
41. UL723 Surface Burning Characteristics of Building Materials

1.06 QUALITY ASSURANCE

A. Substitution of Materials: Refer to Division 1 for equals and substitutions.
   1. Where the following conflicts with Division 1, the requirements of Division 1 shall govern.
   2. If the Contractor wishes to submit an alternate to the named manufacturers for any equipment, he may submit a voluntary alternative minimum 7 days prior to bid, stating the manufacturer’s name, model number, written, detailed product data.
   3. Where materials or equipment are specified by name the proposed material or equipment must be identical to the specified material or equipment in all characteristics of quality, function and serviceability, regardless of application in the Project and, in addition, when the Architect deems that aesthetic significance is important, the equal material or equipment must be identical in all characteristics of visual appearance, design, color and texture. Any proposed equal shall be submitted to Architect/Engineer for prior approval, which Architect/Engineer may approve or disapprove in its sole discretion. Work performed or constructed with unapproved equals is at Contractor’s risk and any required correction of work incorporating unapproved equals shall be at Contractor’s sole cost and expense.

4. In all instances, Contractor shall assume full responsibility for proof of equality of the statute to the equipment hereinafter specified. All data and information necessary for proof of equality, function and space requirements shall be prepared and accompany the submittal of the substitution to the Architect/Engineer. Approval by the Architect/Engineer of equipment other than the specified does NOT relieve Contractor of this responsibility.

B. All products and materials used are to be new, undamaged, clean and in good condition. Existing products and materials are not to be reused unless specifically indicated.

C. Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the contractor is responsible for all costs involved in integrating the equipment/electrical or accessories into the system, including but not limited to, coordination with other trades and any required changes by other trades and for obtaining the performance from the system into which these items are placed. This may include changes found necessary during the testing, adjusting, and balancing phase of the project.

1.07 GUARANTEE

A. Refer to Division 1 for Guarantees and Warranties. In addition to the requirements in Division 1, this Contractor shall meet the following requirements.

B. In entering into a contract covering this work, the contractor accepts the specifications and guarantees that the work will be carried out in accordance with the requirements of this specification or such modifications as may be made under the contract documents.

C. Contractor further guarantees that the workmanship and material will be of the best procurable and that none but experienced workmen familiar with each particular class of work will be employed.

D. Contractor further guarantees to replace and make good at his own expense, including travel time, all defects, which may develop within 1 year after final payment and acceptance by the Architect/Engineer, due to faulty workmanship or material, upon, receipt of written notification from the Owner.

1.08 WORK BY OWNER

A. Asbestos abatement will be performed by the Owner under separate contract.

B. Test and balance services will be provided by the Owner under separate contract.

C. All Division 26 work is being provided by others.

1.09 EQUIPMENT FURNISHED BY OTHERS

1.10 PROVISIONS FOR FUTURE

1.11 OPERATION AND MAINTENANCE INSTRUCTIONS

A. Refer to Division 1 for all operations and maintenance instructions.

B. In addition to the general content specified under Division 1 supply the following additional documentation:

1. Copies of all approved shop drawings along with approval letters.
2. Manufacturer's wiring diagrams for electrically powered equipment
3. Records of tests performed to certify compliance with system requirements
4. Certificates of inspection by regulatory agencies
5. Temperature control record drawings and control sequences
6. Parts lists for manufactured equipment
7. Valve schedules
8. Lubrication instructions, including list/frequency of lubrication done during construction
9. Warranties
10. Additional information as indicated in the technical specification sections

1.12 RECORD DOCUMENTS

A. Refer to Division 1 for record documents.

B. In addition to the general content specified under Division 1, follow the following procedures.

1. During the progress of the work, Contractor shall maintain a current (daily) record set of the drawings and specifications, indicating thereon all work installed at variance with such Contract

Documents including, without limitation, work covered by Addenda, Field Work Orders, Change Orders and Engineers additional instructions, interpretations and clarification. All changes or deviations from the original layout of the work and all critical dimensions of buried or concealed work shall be recorded. It shall be Contractor's responsibility to assure that said record sets are complete, accurate and up-to-date, Engineer shall have the right to inspect and review such record sets.

2. At the completion of the work, Contractor shall indicate on record sets all record changes and such additional details necessary or appropriate to provide a complete reference document for use by Engineer. If variations and details cannot be shown clearly thereon, the Contractor shall prepare supplemental drawings adequate to impart the information. The foregoing drawings collectively shall constitute the "Record" drawings for the work.
3. All indication on "Record" drawings shall be executed in a legible manner at Contractor's cost, using methods and legend presentations compatible with the overall scheme of the record drawings with respect to scale, drawing sheet sizes and sequential indexing. All changes shall be marked clearly in red and clouded.
4. Engineer may review Contractor's "Record" drawings and notify Contractor of observed discrepancies or deviations. Contractor shall promptly correct discrepancies, deviations or illegible markups at Contractor's expense and resubmit revised drawings for Engineer review.
5. Contractor shall provide final electronic record drawings to the Owner through the Engineer.
6. Engineer will provide final electronic record drawings to the Owner based on Contractor's markups.

C. In addition to the data indicated in the Division 1, maintain temperature control record drawings on originals prepared by the installing contractor/subcontractor. Include copies of these record drawings with the Operating and Maintenance manuals.

1.13 CONTINUITY OF EXISTING SERVICES

A. Do not interrupt or change existing services without prior written approval from the Owner's Project Representative. When interruption is required, coordinate scheduling of down-time with the Owner to minimize disruption to his activities. Unless specifically stated, all work involved in interrupting or changing existing services is to be done during normal working hours.
B. Each Contractor shall thoroughly familiarize himself with existing systems which will affect and be affected by relocation of existing equipment and installation of new lines and equipment. They shall plan installation of their work so that interruptions of services to any building or portion thereof will be a minimum and such interruptions shall occur only when system is not required, if possible. If not possible, each Contractor shall insure the operation of services by whatever means possible, such as, installing bypasses, capping of services or providing temporary service. Each interruption shall be for as short a duration as possible.
C. No extra costs will be paid to the Contractor for such outages which must occur outside of regular weekly working hours.
D. This Contractor shall restore any circuit interruption as a result of this work to proper operation as soon as possible. Note that institutional operations are on a seven-day week schedule.

1.14 PROTECTION OF FINISHED SURFACES

A. Refer to Division 1 for protection of finished surfaces.
B. Furnish one aerosol spray can of touch-up paint for each different color factory finish which is to be the final finished surface of the product. Deliver touch-up paint with other "loose and detachable parts" per Division 1.

1.15 SEALING AND FIRESTOPPING

A. Sealing, fireproofing patching, fire caulking and firestopping of sleeves/openings between ductwork, piping, etc. and the sleeve, structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening. The contractor responsible shall hire individuals skilled in such work to do the sealing and fireproofing. These individuals hired shall normally and routinely be employed in the sealing and fireproofing occupation.

B. Contractor shall request current life safety drawings from Architect/Owner.

1.16 OFF SITE STORAGE

A. If payment will be requested for approved offsite stored material, then the Contractor shall complete an "Off-site Storage Agreement" which is available from the Owner. Prior approval by Owner's personnel for offsite storage will be needed. No material will be accepted for offsite storage unless submittals for the material have been approved.

1.17 REGULATORY REQUIREMENTS

A. Comply with requirements of Wisconsin Administrative Code and local Authority Having Jurisdiction (AHJ) regarding materials and installation.

1.18 CERTIFICATES AND INSPECTIONS

A. Refer to Division 1 for permits, regulations, utilities and taxes.
B. Obtain and pay for all required State or local installation inspections except those provided by the Architect/Engineer in accordance with State Code. Deliver originals of these certificates to the Owner. Include copies of the certificates in the Operating and Maintenance Instructions.
C. Coordinate and provide inspections as required by the Authority Having Jurisdiction over the site.
D. Where applications are required for procuring services to the Building, prepare and file such application with the utility company. Furnish all information required in connection with the application in the form required by the utility company.

1.19 COORDINATION

A. Refer to Division 1 for coordination. In addition to the requirements specified under Division 1, the following requirements apply.
B. It shall be the responsibility of each Contractor to coordinate and consult with each other to determine space requirements and to determine that adequate space for servicing is provided for all equipment whether furnished by the Contractor or others. The General Contractor shall have final decision on all space priority conflicts among Contractors. All space priority conflicts shall be brought to the attention of the Architect/Engineer and Owner's Representative.
C. Each Contractor shall thoroughly familiarize himself with existing systems which will affect and be affected by relocation of existing equipment and installation of new lines and equipment. They shall plan installation of their work so that interruptions of services to any building or portion thereof will be a minimum, and such interruptions shall occur only when system is not required, if possible. If not possible, each Contractor shall insure the operation of services by whatever means possible, such as, installing bypasses, capping of services, or providing temporary service. Each interruption shall be for as short a duration as possible.
D. Cooperation among all Contractors shall be required. Any Work that is installed without cooperating or coordinating with other Contractors and is in conflict shall be removed and reinstalled at that particular Contractor's cost. No cost additions to the Project will be considered due to a Contractor's lack of participation in the cooperation and coordination process. The following list of items of Work shall be the priority of order for all Contractors:
    1. Structure
    2. Recessed light fixtures
    3. Gravity-flow systems for sanitary, storm, steam and steam condensate piping
    4. Ductwork and appurtenances
    5. Electrical and low voltage cable tray
    6. Plumbing vent piping
    7. Fire protection (sprinkler system)
    8. HVAC piping
    9. Gas piping, process piping and domestic water
    10. Electrical conduit and low voltage conduit
    11. Control air lines or conduit
E. The above list, in descending order, is the precedence assigned the Work items for space priority. Gravity-flow systems have first priority.

F. Exception: Plumbing lines below or behind plumbing fixtures shall have precedence over all other work. Electrical conduit above or below switchgear, panelboards and control panels shall have precedence over all other work. Do not install any fluid conveying piping over electrical or elevator equipment.

G. In the case of interconnection of the work of two or more contractors, verify at the site or on shop drawings all dimensions relating to such work. All errors due to the failure to so verify any such dimensions shall be promptly rectified.

H. Any installed work that is not coordinated and interferes with another contractor's work shall be removed or relocated at the installing contractor's expense.

I. Prior to start of Construction, the General Contractor shall schedule a meeting with all of the Contractors responsible for the work items listed above. The purpose of the meeting is to introduce the coordination program and to determine its implementation in relation to the progress schedule.

J. At the initial Coordination Meeting, the Mechanical Contractor / Ventilating Contractor shall provide to the General Contractor outline drawings at 1/4" scale indicating column centerlines, interior partition locations, and ceiling heights. The General Contractor shall verify all information shown on these drawings and relay any changes in the information to the Ventilation Contractor to be reflected on the Drawings. The Ventilating Contractor, with reference and consideration to the Structural, Heating, Electrical, Fire Protection, and Plumbing Drawings, shall draw to scale his proposed installation showing duct sizes, equipment layouts, and dimensions from column lines and from finished floors to bottom of ducts. Ductwork shall be maintained as tightly as possible to the underside of floor slabs and/or beams. For congested areas the Ventilating Contractor shall, in addition, prepare Drawings in section view. During this phase of the program, it shall be the Electrical Contractor's responsibility to furnish the Ventilating Contractor with recessed lighting installation and clearance requirements. This information shall be outlined on the Drawings by the Ventilating Contractor.

K. The ductwork layouts shall be produced in sequence as mandated by the Project Schedule. The earliest area indicated in the Schedule shall receive the first effort, etc.

L. When the Ductwork Drawings for the earliest scheduled area have been completed (time limitation as determined at the initial coordination meeting), the Ventilating Contractor shall provide the General Contractor with one set of drawings for each participant in the effort. The General Contractor will distribute the drawings to the participating Contractors for their use in drawing thereon the major components of their proposed installation using the general scheme shown on the Contract Drawings as a guide.

M. The major components to be indicated include (but are not limited to) the following:
   1. Structure
   2. Sprinkler mains
   3. Heating hot water mains
   4. Significant conduit runs
   5. Contract ceiling heights
   6. Soffits
   7. Access points
   8. Fire wall penetrations

N. Information delineated shall be distance from column centerlines, pipe/equipment size, and distance from finished floor to bottom of pipe/equipment and hangers. Included on the Drawings shall be piping layout with hanger locations and hanger point loads. This information shall be developed satisfactorily enough to allow the Structural Engineer to verify the adequacy of the structural system for the projected loads. The hanger locations may have to be moved depending on the structural system review. No hanger shall be fabricated and/or installed until the hanger locations are reviewed and accepted by the Architect/Engineer.

O. Within a period not to exceed two weeks after distribution of the drawings, the General Contractor will schedule a meeting with the Architect/Engineer and participating Contractors at which time areas of conflict shall be resolved. The drawings shall be overlaid to identify areas of conflict. All parties shall then cooperate in resolving the conflicts. Records of the agreements shall be entered on the Ventilating Contractor's drawings, acknowledged by all participants by signature in space provided for this purpose, and two copies distributed to all involved parties. All coordination drawing preparation and reproduction costs shall be borne by the Ventilating Contractor. The above drawings, review, and coordination process shall be repeated until all areas on the Project have been coordinated.

P. In the event a Contractor fails to cooperate in the Coordination Program, they shall be held responsible for all costs incurred for adjustments to the work of others made necessary to accommodate the uncooperative Contractor's installations.

1.20 DEMOLITION AND EXISTING REQUIREMENTS

A. Existing active services: water, gas, medical gas, steam, ventilation, compressed or control air, sanitary waste, sanitary vent, storm electric, and any other building systems when encountered shall be protected against damage. Where existing services are to be abandoned, the services shall be removed back to the point of origin and removed from the site unless otherwise directed by the Owner's Representative.

B. Submit a "Sequence of Work Schedule" in respect to all temporary and permanent utility and service cutovers after final determination. This schedule shall be submitted for approval to the Owner and Architect/Engineer. The submittal shall designate priority order, service or utility affected, date of cutover, and time of day to start and finish.

C. Bidders should inspect the site to become familiar with conditions of the site which will affect the Work. Bidders should verify points of connection with utilities, routing of outside piping to include required clearances from any existing structures, or other obstacles.

D. Extra payment will not be allowed for changes in the Work required because of the successful bidder's failure to make this inspection.

1.21 REQUEST AND CERTIFICATION FOR PAYMENT

A. Within 10 days after Notice to Proceed, the successful bidder will submit to the Owner's Project Representative in a form prescribed by Division 1, a cost breakdown of the proposed values for work performed which, if approved by the owner, will become the basis for construction progress and monthly payments. The cost breakdown items shall reflect actual work progress stages as closely as feasible.

B. In addition, if payment is requested for approved off-site stored material, then that material shall be listed as a line item in the request and certification for payment cost breakdown.

1.22 SLEEVES AND OPENINGS

A. Openings required in new or existing construction that may be necessary for the installation of new work shall be provided by the respective contractor and all patching and repairing shall be done by workmen competent in the trade required, at the expense of the respective contractor. The respective contractor shall be responsible for arranging the work so that minimum cutting will be required. All rubbish and excess materials involved in such cutting shall be promptly removed from the site and disposed of by the contractor. Cutting through the floor or roof systems or load bearing walls shall be done only with the prior written approval of the Architect/Engineer so as to avoid damaging the structural system.

1.23 OMISSIONS

A. No later than ten (10) days before bid opening, the Contractor shall call the attention of the A/E to any materials or apparatus the Contractor believes to be inadequate and to any necessary items of work omitted.

1.24 DEFINITIONS

A. The term "provide" includes such labor, methods, materials, equipment and transportation or other facilities required to complete the Contract and the performance of all duties thereby upon the Contractor.

1.25 PROJECT/SITE CONDITIONS

A. Install Work in locations shown on Drawings, unless prevented by Project conditions.

B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission of A/E before proceeding.

C. Tools, materials and equipment shall be confined to areas designated by the Owner's project representative.

1.26 WORK SEQUENCE AND SCHEDULING

A. Install work in phases to accommodate Owner's occupancy requirements. During the construction period coordinate schedule and operations with Owner's Construction Representatives.

1.27 SALVAGE MATERIALS

A. No materials removed from this project shall be reused (except as specifically noted below). All materials removed shall become the property of and shall be disposed of by the Contractor.

1.28 TRAINING

A. Video recording of the training sessions will be provided by the contractor and added to the O&M manuals. In addition, factory training videos identifying key troubleshooting, repair, service and/or replacement techniques shall be provided and reviewed with the owner.
B. Provide a minimum of 16 hours of instruction.
C. Provide additional training as specified in other specification sections for specific equipment.

PART 2 - PRODUCTS

2.01 ACCESS PANELS AND DOORS

A. Lay-In Ceilings:
   1. Removable lay-in ceiling tiles in 2 X 2 foot or 2 X 4-foot configuration provided under Division 9 are sufficient; no additional access provisions are required unless specifically indicated.
B. Concealed Spline Ceilings:
   1. Removable sections of ceiling tile held in position with metal slats or tabs compatible with the ceiling system used will be provided under Division 9.
C. Metal Pan Ceilings:
   1. Removable sections of ceiling tile held in position by a pressure fit will be provided under Division 9.
D. Plaster Walls and Ceilings:
   1. 16-gauge frame with not less than a 20-gauge hinged door panel, prime coated steel for general applications, stainless steel for use in toilets, showers, and similar wet areas, concealed hinges, screwdriver operated cam latch for general applications, key lock for use in public areas, UL listed for use in fire rated partitions if required by the application. Use the largest size access opening possible, consistent with the space and the equipment needing service; minimum size is 12" by 12".

2.02 IDENTIFICATION

A. Piping and ductwork labels shall follow owner’s labeling and naming standards.
B. Stencils:
   1. Not less than 1-inch high letters/numbers for marking pipe and equipment.
C. Snap-On Pipe Markers:
   1. Cylindrical self-coiling plastic sheet that snaps over piping insulation and is held tightly in place without the use of adhesive, tape or straps. Not less than 1-inch high letters/numbers and flow direction arrows for piping marking. W. H. Brady, Seton, Marking Services.
D. Engraved Name Plates:
   1. White letters on a black background, 1/16-inch-thick plastic laminate, beveled edges, screw mounting, Setonply Style 2060 by Seton Name Plate Company or Emedolite- Style EIP by EMED Co., or equal by Marking Services, or W. H. Brady.
E. Valve Tags:
   1. Round brass tags with 1/2-inch numbers, 1/4-inch system identification abbreviation, 1-1/4-inch minimum diameter, with brass jack chains or brass "S" hooks around the valve stem, available from EMED Co., Seton Name Plate Company, Marking Services, or W. H. Brady.

2.03 SLEEVES AND OPENINGS

A. General:

1. Pipe sleeves shall be constructed of standard weight ASTM A53 or ASME B36.10 steel with an anchor plate constructed of A36/A36M steel welded to the pipe. The sleeve shall be sized a minimum of 1" larger than piping insulation diameter. The entire assembly shall be hot-dip galvanized after fabrication.
2. Duct sleeves and piping sleeves passing through interior walls shall be constructed of 24-gauge galvanized steel minimum thickness.

B. Sleeves Through Below Grade Walls:
1. Provide steel pipe sleeve, ASTM A53, pressure sealing with membrane clamp ring, gasket, water stop ring, external rings, and nitrile rubber link seals. The assembly shall be hot-dip galvanized after fabrication.
    a. Seals: Modular mechanical type seals, consisting of interlocking nitrile rubber links shaped to continuously fill the annular space between the pipe and the sleeve and electrically isolate the carrier pipe from the steel sleeve.
    b. Sealing Element: Polychloroprene rubber material compounded to resist aging, ozone, sunlight, hydrocarbon gases, water, and chemical action.
    c. Hardware: Type 300 series stainless steel fasteners. Threads rolled to produce smooth uniform threads and unbroken flow lines.
    d. Compression Plates: Fiberglass-reinforced polyester plastic, injection molded for high physical properties, dielectric strength and non-cold flow creep characteristics, having high resistance to acidic and alkaline soils.
2. For sleeves located 15 feet or more below grade provide cast iron sleeve ASTM A74 with compression seals.

2.04 SEALING AND FIRESTOPPING

A. Fire And/or Smoke Rated Penetrations:
1. Manufacturers: 3M, Hilti, Rectorseal, STI/SpecSeal, Tremco.
2. All firestopping systems shall be provided by the same manufacturer.
3. Submittals: Contractor shall submit product data for each firestop system. Submittals shall include product characteristics, performance and limitation criteria, test data, MSDS sheets, installation details and procedures for each method of installation applicable to this project. For non-standard conditions where no UL tested system exists, submit manufacturer's drawings for UL system with known performance for which an engineering judgment can be based upon.
4. Product:
    a. Fire stop systems shall be UL listed or tested by an independent testing laboratory approved by the Owner and the Authority Having Jurisdiction (AHJ).
    b. Use a product that has a rating not less than the rating of the wall or floor being penetrated. Reference architectural drawings for identification of fire and/or smoke rated walls and floors.
    c. Contractor shall use firestop putty, caulk sealant, intumescent wrap strips, intumescent firestop collars, firestop blocks, firestop mortar or a combination of these products to provide a UL listed system for each application required for this project. Provide mineral wool backing where specified in manufacturer's application detail.
    d. All sealants shall meet the intent of LEED® VOC requirements, <250 g/L VOC contents (less H_20 and exempt solvents).

B. Non-Rated Penetrations:
1. Pipe Penetrations Through Below Grade Walls: In exterior wall openings below grade, use a modular mechanical type seal consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the uninsulated pipe and the cored opening or a water-stop type wall sleeve. The operating bolts of the mechanical type seal shall be accessible from the building interior.
2. Pipe Penetrations: At pipe penetrations of non-rated interior partitions, floors and exterior walls above grade, use urethane caulk in annular space between pipe insulation and sleeve. For non-rated drywall, plaster or wood partitions where sleeve is not required use urethane caulk in annular space between pipe insulation and wall material.
3. Duct Penetrations:
    a. Annular space between duct (with or without insulation) and the non-rated partition or floor opening shall not be larger than 2". Where existing openings have an annular space larger

than 2", the space shall be patched to match existing construction to within 2" around the duct.

b. Where shown or specified, pack annular space with fiberglass batt insulation or mineral wool insulation. Provide 4" sheet metal escutcheon around duct on both sides of partition or floor to cover annular space.

PART 3 – EXECUTION

3.01 DEMOLITION

A. Perform all demolition as indicated on the drawings to accomplish new work. Where demolition work is to be performed adjacent to existing work that remains in an occupied area, construct temporary dust partition to minimize the amount of contamination of the occupied space. Where pipe or duct is removed and not reconnected with new work, cap ends of existing services as if they were new work. Coordinate work with the owner to minimize disruption to the existing building occupants.

B. All pipe, wiring and associated conduit, insulation, ductwork, and similar items demolished, abandoned, or deactivated are to be removed from the site by the Contractor. All piping and ductwork specialties are to be removed from the site by the Contractor unless they are dismantled and removed or stored by the owner. All designated equipment is to be turned over to the owner for their use at a place and time so designated. Maintain the condition of material and/or equipment that is indicated to be reused equal to that existing before work began.

C. All contractors requiring the personnel/ material hoist and or temporary construction elevator (i.e. new elevators, temporarily protected) at times other than outlined in the temporary facilities specifications will make arrangements directly with the general contractor. The general contractor is responsible for all coordination and scheduling of the use of any hoisting equipment, so the flow of the project is smoothly maintained, and all workers have access to the work areas to perform their work and deliver material to the areas needed according to the project schedule.

D. If any contractor’s work requires the removal and replacement of any finished materials including but not limited to such materials as ceiling tiles, wall finishes, cabinets, doors, flooring, windows, etc. after those items are installed, each contractor will be responsible, at no additional cost to the owner, to replace any damaged, soiled or lost materials with new materials to match the existing materials and those materials damaged.

3.02 CUTTING AND PATCHING

A. Refer to Division 1 for cutting and patching. In addition to the requirements in Division 1:

B. Each Contractor shall coordinate the placing of openings in the new structure as required for the installation of each Contractor’s work.

C. Each Contractor shall furnish to the General Contractor the accurate locations and sizes for required openings in the new work, but this shall not relieve each Contractor of the responsibility of checking to assure that properly sized openings are provided. When additional patching is required due to the Contractor's failure to inspect this work, then the Contractor shall make arrangements for the patching required to properly close the openings to include patch painting, and the Contractor shall pay any additional cost incurred in this respect.

D. If cutting and patching of the new structure is made necessary due to the Contractor's failure to install piping, ducts, sleeves, or equipment on schedule, or due to the Contractor's failure to furnish on schedule the information required for the leaving of openings, then it shall be the Contractor's responsibility to make arrangements and obtain approval from the General Contractor and Architect/Engineer for this cutting and patching, and the Contractor shall pay any additional cost incurred in this respect. The Contractor shall also reimburse the Owner for any additional costs incurred to the Architect/Engineer for additional services caused by the Contractor in this respect.

E. The Contractor shall provide cutting and patching and patch painting in the existing structure as required for the installation of his Work and shall furnish lintels and supports as required for openings. Cutting of structural support members will not be permitted without prior approval of the Architect/Engineer. Extent of cutting shall be minimized; use core drills, power saws, or other

machines which will provide neat, minimum openings. Patching shall match adjacent materials and surfaces and shall be performed by craftsmen skilled in the respective craft required.

3.03 LINTELS

A. All steel lintels required for opening in existing and/or new masonry walls shall be provided under section 05 50 00 – Metal Fabrications. This contractor shall design, fabricate, and install all lintels required in masonry walls for duct and pipe penetrations. Contractor shall submit design drawings of lintels with professional engineer's seal and signature prior to installation.

3.04 BUILDING ACCESS

A. Arrange for the necessary openings in the building to allow for admittance of all apparatus. When the building access was not previously arranged and must be provided by this contractor, restore any opening to its original condition after the apparatus has been brought into the building.

3.05 EQUIPMENT ACCESS

A. Install all piping, conduit, ductwork, and accessories to permit access to equipment for maintenance and service. Coordinate the exact location of wall and ceiling access panels and doors with the General Contractor, making sure that access is available for all equipment and specialties. Access doors in general construction are to be furnished by the Mechanical Contractor and installed by the General Contractor.

B. Provide color coded thumb tacks or screws, depending on the surface, for use in accessible ceilings which do not require access panels.

3.06 COORDINATION

A. Verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to, diffusers, register, grilles, and recessed or semi-recessed heating and/or cooling terminal units installed in/on architectural surfaces.

B. Coordinate all work with other contractors prior to installation. Any installed work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.

C. Cooperate with the test and balance agency in ensuring compliance with Section 23 05 93 – Testing, Adjusting and Balancing for HVAC. Verify system completion to the test and balance agency (flushing, pressure testing, chemical treatment, filling of liquid systems, proper pressurization and air venting of hydronic systems, clean filters, clean strainers, duct and pipe systems cleaned, controls adjusted and calibrated, controls cycled through their sequences, etc.), ready for testing, adjusting and balancing work. Install dampers, shutoff and balancing valves, flow measuring devices, gauges, temperature controls, etc., required for functional and balanced systems. Demonstrate the starting, interlocking and control features of each system so the test and balance agency can perform its work.

3.07 IDENTIFICATION

A. Identify equipment in mechanical equipment rooms by stenciling equipment number and service with one coat of black enamel against a light background or white enamel against a dark background. Use a primer where necessary for proper paint adhesion. Do not label equipment such as cabinet heaters and ceiling fans in occupied spaces.

B. Where stenciling is not appropriate for equipment identification, engraved name plates may be used.

C. Identify piping not less than once every 30 feet, not less than once in each room, adjacent to each access door or panel, and on both side of the partition where exposed piping passes through walls, floors or roofs. Place flow directional arrows at each pipe identification location. Piping and ductwork labels shall follow owner's labeling and naming standards. Use one coat of black enamel against a light background or white enamel against a dark background for stenciling or provide snap on pipe markers as specified in Part 2 – Products.

D. Identify valves with brass tags bearing a system identification and a valve sequence number. Valve tags are not required at a terminal device unless the valves are greater than ten feet from the device or located in another room not visible from the terminal unit. Provide a typewritten valve schedule indicating the valve number and the equipment or areas supplied by each valve; locate schedules in

each mechanical room and in each Operating and Maintenance manual. Schedules in mechanical rooms to be framed under clear plastic.

E. Use engraved name plates to identify control equipment.

F. Label fire, smoke and combination fire smoke dampers on the exterior surface of ductwork directly adjacent to access doors using a minimum of 0.5-inch height lettering reading, “SMOKE DAMPER” or “FIRE DAMPER”. Smoke and combination fire smoke dampers shall also include a second line listing the individual damper tag. The tags must be coordinated with the mechanical schedules. Utilize stencils or manufactured labels. All other forms of identification are unacceptable. All labels shall be clearly visible from the ceiling access point.

3.08 LUBRICATION

A. Lubricate all bearings with lubricant as recommended by the manufacturer before the equipment is operated for any reason. Once the equipment has been run, maintain lubrication in accordance with the manufacturer's instructions until the work is accepted by owner. Maintain a log of all lubricants used and frequency of lubrication; include this information in the Operating and Maintenance Manuals at the completion of the project.

3.09 SLEEVES AND OPENINGS

A. General:
   1. Sleeves are not required for piping and ducts passing through interior non-rated drywall, plaster, or wood partitions and interior poured concrete walls that have been saw cut or core drilled.
   2. Pack annular space between sleeves and pipe or ducts with fiberglass insulation and seal.
   3. Piping sleeves that pass-through fire rated floors, walls, or ceilings shall be provided with a UL listed fire stop material meeting UL 1479 to seal the opening between the pipe and the pipe sleeve to maintain the fire rating.
   4. Provide escutcheon plates on piping to cover sleeve and insulation in finished areas.
   5. Refer to Division 1 for additional information on sleeves and openings.

B. Sleeves Through Floors/Ceilings:
   1. Sleeves shall be installed to extend 1 inch above finished floor with a watertight sealant between floor and sleeve in all mechanical rooms and wet rooms listed below.
   2. If a sleeve is not provided, provide 1-1/2-inch angle ring with urethane caulk between the angle and the floor and seal at the corners to form a watertight seal.
      a. Wet Locations:
         1) Mechanical Rooms
         2) Parking Ramps
         3) Sanitary pumping stations
         4) Storm Pumping Stations
         5) Swimming pool equipment rooms
         6) Chemical storage and hazardous waste storage rooms
         7) Food service/kitchen areas (behind/under equipment, cabinets, tables, etc.)

3.10 SEALING AND FIRESTOPPING

A. The Contractor shall refer to building life safety drawings for all smoke and fire rates in addition to the mechanical drawings. Any discrepancies shall be brought to the attention of the Architect/Engineer before final addendum.

B. Fire and/or Smoke Rated Penetrations:
   1. Install approved product in accordance with the manufacturer's instructions where pipes penetrate a fire/smoke rated surface. When pipe is insulated, use a product which maintains the integrity of the insulation and vapor barrier.
   2. Where firestop mortar is used to infill large fire-rated floor openings that could be required to support weight, provide permanent structural forming. Firestop mortar alone is not adequate to support any substantial weight.

C. Non-Rated Partitions:
   1. In exterior wall openings below grade, assemble rubber links of mechanical seal to the proper size for the pipe and tighten in place, in accordance with manufacturer's instructions.

2. At all interior partitions and exterior walls, pipe penetrations are required to be sealed. Apply sealant to both sides of the penetration in such a manner that the annular space between the pipe sleeve or cored opening and the pipe or insulation is completely blocked.
3. Duct penetrations through non-rated partitions shall require sheet metal escutcheons with fiberglass or mineral wool insulation fill for spaces that include laboratories, clean rooms, animal rooms, kitchens, cart wash rooms, janitor closets, toilet rooms, mechanical rooms, conference rooms, private consultation rooms, and where noted on drawings elsewhere.

3.11 HOUSEKEEPING AND CLEAN UP

A. The Contractor shall clean up and remove from the premises, on a daily basis, all debris and rubbish resulting from its work and shall repair all damage to new and existing equipment resulting from its work. When job is complete, this Contractor shall remove all tools, excess material and equipment, etc., from the site.

END OF SECTION

SECTION 23 05 14
VARIABLE FREQUENCY DRIVES

PART 1 – GENERAL

1.01 SCOPE OF WORK
A. Base Bid:
   1. Mechanical Contractor provide: Variable Frequency Drives for pumps, cooling tower and chillers as specified herein and shown on the drawings.
   2. Mechanical Contractor provide: Variable Frequency Drives for air handling units, energy recovery wheels and fans as specified herein and shown on the drawings.

1.02 SECTION INCLUDES
A. This section includes variable frequency drives, bypass starters and line reactors. Included are the following topics:
   1. Variable Frequency Drives
   2. Variable Frequency Drives with Bypass

1.03 RELATED WORK
A. Applicable provisions of Division 1 govern work under this section
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 09 93 – Sequence of Operations for HVAC Controls
D. Section 26 05 26 – Grounding and Bonding for Electrical Systems
E. Section 26 05 29 – Hangers and Supports for Electrical Systems
F. Section 26 05 53 – Identification for Electrical Systems
G. Section 26 27 02 – Equipment Wiring Systems

1.04 SUBMITTALS
A. Refer to Section 23 05 00 – Common Work Results for HVAC, Submittals. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Variable Frequency Drives
   2. Variable Frequency Drives with Bypass
B. Include physical, electrical, and performance characteristics of each variable frequency drive and associated components, including dimensions; weight; input and output performance; voltage, phase, current and overcurrent characteristics; installation instructions; protective features; wiring and block diagrams indicating specified options; electrical noise attenuation equipment where required to meet the criteria specified; line side voltage notch wave form and line side current harmonics; certified efficiency versus load and speed curves; and required operating environment.

1.05 REFERENCE STANDARDS
A. ANSI/IEEE 519 Guide for Harmonic Control and Reactive Compensation of Static Power Converters

1.06 WARRANTY
A. The warranty shall be for a period of twenty-four (24) months from the date of project Substantial Completion. Further, the warranty shall include all parts, labor, travel time, administrative costs, overhead, travel expenses, technical support and any and all other costs to provide the warranty service.

1.07 OPERATION AND MAINTENANCE DATA
A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 – Common Work Results for HVAC.

1.08 EQUIPMENT STARTUP

A. The start-up services will be performed as part of the start-up of the RTU. The RTU start-up will be performed by a factory trained and certified technician to approve the installation; start-up, test, and adjust for proper operation of the unit(s). Upon completion of the equipment startup, submit a complete manufacturer's field report, including startup and test log, signed by the factory trained technician. Coordinate with the Temperature Control Contractor and the Balancing Contractor. The startup shall be coordinated with Division 26. Electrical and shall be completed within ten (10) working days from the startup date as set by the owner's representative.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. ABB, Toshiba, Danfoss, Trane/Danfoss, GE Fuji, Emerson, Yaskawa, Eaton/Cutler Hammer, Mitsubishi, Allen Bradley

2.02 DESIGN AND CONSTRUCTION

A. The unit shall be variable torque, modular design for control of the motors as specified in Division 23 and rated at the motor full load nameplate amps.
B. The unit shall be U.L. listed, solid state, microprocessor-based with a pulse width modulated (PWM) output wave form (none others are acceptable).
C. The VFD shall employ a full wave bridge rectifier and capacitors to minimize the ripple of the rectified voltage to maintain near constant DC voltage. Insulated gate bipolar transistors (IGBT's) shall be employed as the output switching device.
D. The VFD package shall contain the equivalent of 5% impedance to reduce harmonic distortion. The 5% equivalent impedance shall be provided in the form of a DC bus choke, an input AC line reactor in each phase, or a combination of the two methods.
E. Control circuitry shall be plug-in, plug-out modular basis with a corrosion resistant coating on printed circuit boards.
F. Units to be suitable for an operating environment from 32°F to 104°f temperature and humidity up to 90% non-condensing.
G. Electrically and physically isolate control circuitry and conductors from power circuitry and power conductors. Control conductors and power conductors shall not be run in the same pathway.
H. All power wiring from the VFD output to the motor shall be type XHHW-2 insulation, single conductor wire.
I. The unit enclosure shall be NEMA 1 as required for the application minimum and all components shall be fully factory assembled and tested prior to leaving the manufacturing facility.
J. Include the following operating and monitoring devices mounted on the front cover:
    1. A disconnect switch or circuit breaker to de-energize both the drive and bypass circuit with door interlocked handle and lock-open padlocking provisions
    2. Operating mode selector switch marked "hand-off-auto"
    3. Manual speed adjustment via keypad, mounted on the door
    4. Manual bypass selector switch to select power through drive or bypass (if a bypass is provided)
K. Provide a manual bypass circuit and bypass starter to transfer from variable frequency drive operation to bypass operation (if a bypass is provided).
L. Provide a backup VFD circuit and VFD controller to transfer from variable frequency drive operation to backup VFD operation (if a backup VFD is provided).

2.03 PERFORMANCE REQUIREMENTS

A. Units shall be suitable for input power of electrical system as scheduled on the drawings ±10%, 3 phase, 60 Hertz nominal.
B. Use a current limiting control device to limit output current to 110% continuous for one minute; also refer to Protection Features in this section. Full load output current available from drive shall not be less than motor nameplate amperage. The full load amp rating of the VFD shall not be less than the values indicated in the NEC Table 430-150.
C. Output power shall be suitable for driving standard NEMA B design, three phase alternating current induction motors at full rated speed with capability of 6:1 turndown.

D. Additional performance capabilities to include the following:
   1. Ride through a momentary power outage of 15 cycles
   2. Start into a rotating load without damage to drive components or motor
   3. Capable of automatic restart into a rotating load after a preset, adjustable time delay following a power outage
   4. Input power factor: Min 0.95 throughout the speed range
   5. Minimum efficiency: 95% at 100% speed, 85% at 50% speed

2.04 CONTROL FEATURES

A. Use control circuits compatible with input signal from temperature control system in the automatic mode and from manual speed control in the manual mode. Vary motor speed in response to the input control signal. Include components necessary to accept the signal from the temperature control system in the form that it is sent. Refer to Division 23.

B. Include the following additional control features:
   1. Hand-Off-Automatic (HOA) selector switch to select local or remote start/stop and speed control
   2. Analog input, selectable 0-10v or 4-20 mA, for automatic control from the temperature control system
   3. Local speed control at the VFD
   4. Adjustable acceleration and deceleration rate so that the time period from start to full speed and from full speed to stop can be field adjusted
   5. Adjustable minimum and maximum speed settings for both automatic and manual modes of operation
   6. Manual transfer bypass circuit
   7. Field adjustment of minimum and maximum output frequency
   8. Two (2) sets of programmable form "C" contacts for remote indication of variable frequency drive condition. Note: default programming to be set for "Drive Run & Fault".
   9. Illuminated display keypad.
   10. External Fault indicator
   11. One (1) input for a N.O. dry contact type input for a 2-wire remote start/stop
   12. One (1) input for a N.C. dry contact type input for external faults: (freezestats, fire alarm, smokes, etc.). This input shall be factory wired to prevent both the VFD and bypass starter operation when external fault is present.
   13. One (1) N.O. dry contact output for proving motor status. This output shall be programmed to detect belt or coupling break that would remove the load from the motor. The dry contact will open on loss of load or VFD being off.
   14. PID control loop capable of VFD control from an external device connected to a VFD analog input.

C. The VFD controller shall convert VFD information into the BACnet MSTP protocol that will be compatible with the building direct digital energy management system (EMS) supplied on the project. This output shall be through a serial interface port capable of two-way communication with the building EMS provided on this project. Final connection shall not require any additional intermediate gateway devices to provide throughput of data. The following data shall be provided at a minimum:
   1. Fault condition
   2. Speed
   3. Amperage
   4. Frequency
   5. Voltage
   6. Bypass status (if supplied)

2.05 PROTECTION FEATURES

A. Use electronic protection circuitry in the power circuits to provide an orderly shutdown of the drive without blowing fuses or tripping circuit breakers and prevent component loss under the following abnormal conditions:
   1. Activation of any safety device
   2. Instantaneous overcurrent and/or over voltage of output
   3. Power line overvoltage and undervoltage protection

4. Phase loss
5. Single and three phase short circuiting
6. Ground faults
7. Control circuit malfunction
8. Over temperature
9. Output current over limit.

B. Provide the following additional protective features:
1. Input transient overvoltage protection up to 3000 volts per ANSI 37.90A
2. DC bus fusing or other electronic controls which limit the rate of rise of the DC bus current and de-energizes the drive at a predetermined current level
3. Fusing for the control circuit transformer
4. Grounded control chassis
5. Devices and/or control circuitry to ensure that the variable frequency drive and bypass starter are not both energized and driving motor simultaneously

2.06 DIAGNOSTICS

A. Provide an English character display (no error codes) with indicators for the following:
1. Phase loss
2. Ground fault
3. Overcurrent
4. Overvoltage
5. Under voltage
6. Over temperature
7. Overload
8. DC bus status

2.07 QUALITY ASSURANCE TESTS

A. Use a factory heat stress test to verify proper operation of all functions and components under full load.

B. Field performance test of variable frequency drives to determine compliance with this specification will be performed at the owner's discretion and may include any specified feature, including operation of protective devices through a simulated fault. Contractor will pay for initial testing. Should drive be found deficient by this testing, drive manufacturer will be required to make any and all changes necessary to bring unit(s) into compliance with the specified performance and demonstrate this performance by retesting. Cost of changes and retest will be by this contractor.

C. Variable frequency drive manufacturer or designated representative to perform a field test of each drive, in the presence of the owner's representative, for the following items:
1. Provide general inspection to verify proper installation
2. Demonstrate drive reaction to simulated power interruptions of two seconds and sixty seconds
3. Demonstrate adequate protection during switching from variable frequency drive operation to bypass starter operation and back again

2.08 BYPASS EQUIPMENT

A. Provide VFD with bypass starter for motors of the following equipment as scheduled:
1. Provide all other variable frequency drives without a bypass.

B. Bypass Starters:
1. The bypass starters for 208 volt motors, 20 HP and less; and 480 volt motors, 40 HP and less, shall be across-the-line magnetic starter type.
2. The bypass starters for 208 volt motors, 25 HP and more; and 480 volt motors, 50 HP and more, shall be solid state reduced voltage starting type.

C. Bypass Configuration:
1. Provide one main disconnect switch or circuit breaker to de-energize both the drive and bypass circuit. Provide a drive input disconnect switch or fuse block to allow the drive to be isolated while the bypass circuit is energized. Provide one output drive contactor and one output bypass contactor. The two output contactors shall be electrically interlocked to allow only one contactor to be closed at any one time.

D. Provide motor overload protection in the bypass circuit.

E. Provide bypass equipment in a common enclosure with the VFD or, if not available, in a separate enclosure.

2.09 BACKUP VARIABLE SPEED DRIVES

A. Provide VFD with a backup VFD for motors of the following equipment:
   1. Provide all other variable speed drives without backup drives.

2.10 AC INPUT LINE REACTORS

A. When needed to comply with the requirement for 5% equivalent impedance, furnish and factory install AC input line reactors.
B. Line reactors shall be installed in each phase of the AC input side of the VFD and mounted within a common enclosure with the VFD.
C. Line reactor shall be a three phase inductor, iron core, 600V, Class H insulation, 115 degree C rise, copper windings with screw type terminal blocks.

2.11 OUTPUT LINE FILTER

A. Provide a three phase dV/dT output filter for any 460VAC drive with output line length of over 120 feet or as specified.

PART 3 – EXECUTION

3.01 VARIABLE FREQUENCY DRIVES

A. Install where indicated on drawings and in accordance with approved submittals and manufacturer's published recommendations. Installation to be by the Division 26 - Electrical contractor.
B. Input power wiring shall be installed in a separate conduit, output power wiring shall be installed in a separate conduit and control wiring shall be installed in a separate conduit. Do not mix input power, output power, or control wiring in a common conduit. Separate conduits for input and output power wiring shall be provided for each motor. Input and output power wiring for more than one motor shall not share a common conduit. Power wiring shall be furnished and installed by the Div. 26 contractor. If provided, do not mount output line filter above the drive.
C. Control signal for drive will be provided under Division 23.
D. Temperature Control Contractor will furnish and install the required temperature control wiring in metal conduit and in accordance with Division 26 - Electrical of this specification.

3.02 TRAINING

A. See Section 23 05 00 – Common Work Results for HVAC for general training requirements.
B. In addition to the training provided in Section 23 05 00 – Common Work Results for HVAC, provide an additional 4 hours of training for each type of VFD provided on the project.

END OF SECTION

SECTION 23 05 15
PIPING SPECIALTIES

PART 1 – GENERAL

1.01 SCOPE OF WORK
A. Base Bid: Unless noted otherwise, the Mechanical Contractor shall provide all labor and materials for a complete system in this specification section.

1.02 SECTION INCLUDES
A. This section contains specifications for HVAC piping specialties for all piping systems. Included are the following topics:
   1. Test Wells
   2. P/T (Pressure/Temperature) Test Plugs
   3. Hose Connection Caps
   4. Strainers
   5. Air Vents

1.03 RELATED WORK
A. Applicable provisions of Division 1 govern work under this section.
B. Conform to Standards of Expansion Joint Manufacturer's Association.
C. Section 23 05 00 – Common Work Results for HVAC
D. Section 23 05 23 – General Duty Valves for HVAC Piping
E. Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment
F. Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment
G. Section 23 07 00 – HVAC Insulation
H. Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC
I. Section 23 21 13 – Hydronic Piping

1.04 SUBMITTALS
A. Refer Section 23 05 00 – Common Work Results for HVAC, Submittals. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Test Wells
   2. P/T (Pressure/Temperature) Test Plugs
   3. Hose Connection Caps
   4. Strainers
   5. Air Vents
B. Required for all items in this section. Include materials of construction, dimensional data, ratings/capacities/ranges, pump curves with net positive suction head requirements, pressure drop data where appropriate, and identification as referenced in this section and/or on the drawings.

1.05 REFERENCE STANDARDS
A. ASME B31 Standards of Pressure Piping
B. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
C. ASTM B650 Standard Specification for Electrodeposited Engineering Chromium Coatings on Ferrous Substrates
D. ANSI/AWWA Standard C700 Cold-Water Meters – Displacement Type, Bronze Main Case

1.06 QUALITY ASSURANCE
A. Refer to Division 1 for equals and substitutions.

1.07 DESIGN CRITERIA

A. All piping specialties are to be rated for the highest pressures and temperatures in the respective system in accordance with ASME B31, but not less than 125 psig unless specifically indicated otherwise. Base expansion calculations on 50° F (10° C) installation temperature to 240° F (115° C) for hot water heating. Base expansion calculations on 50° F (10° C) installation temperature to 300° F (150° C) for low pressure (15#) steam and condensate and 400° F (205° C) medium pressure (150#) for steam and condensate. If these temperatures are adjusted at any time, the contractor shall contact the Architect/Engineer in writing before the end of the project.

1.08 WARRANTY

A. For slip expansion joints provide published five (5) year warranty and service guarantee including, but not limited to leak free.

1.09 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 – Common Work Results for HVAC.

PART 2 - PRODUCTS

2.01 TEST WELLS

A. Similar to thermometer sockets except with a brass cap that thread into the inside of the test well to prevent dirt from accumulating. Secure cap to body with a short chain. Furnish with extension necks, where appropriate, to accommodate the pipeline insulation.

2.02 P/T (PRESSURE/TEMPERATURE) TEST PLUGS

A. Brass plug with 1/4" NPT threads, EPDM or neoprene valve core, knurled cap with cap strap. Use extended length plugs to clear insulated piping. Adaptors shall have 1/4" FPT connection for standard pressure gauges.

2.03 HOSE CONNECTION CAPS

A. Hose connection caps shall be pressure rated for 150 psig at 180 deg F.

2.04 STRAINERS

A. Manufacturers: Armstrong, Hoffman, Illinois, Keckley, Metraflex, Mueller Steam, or Sarco.

B. Water Systems: Y type; cast iron body; stainless steel screens; bolted or threaded screen retainer tapped for a blow off valve; threaded body in sizes through 2 inch and rated at not less than 175 psi WOG; flanged body in sizes over 2 inch and rated at not less than 125 psi WOG at 240°F. Screen to be 20 mesh for line sizes 2 inch and less, 0.125 inch perforations for line sizes 2-1/2 inch through 4 inch, and 0.25 inch perforations for line sizes 5 inch and larger.

C. Basket type: Cast iron body with clamped cover; stainless steel screens; body tapped for a blow off valve; 125 psig flanged body for 2 1/2" and larger; 0.125-inch perforations for line sizes 2-1/2 inch through 4 inch, and 0.25-inch perforations for line sizes 5 inch and larger.

D. Water Systems With Design Pressures Over 150 psig: Y type; cast iron or cast steel body; stainless steel screens; bolted or threaded screen retainer tapped for a blow off valve; threaded or socket weld body in sizes through 2 inch and rated at not less than 300 psi WOG at 150°F; flanged or butt weld body in sizes over 2 inch and rated at not less than 300 psi WOG at 150°F. Screen perforations to be 0.057 inch for line sizes 2 inch and less, 0.125 inch for line sizes 2-1/2 inch through 4 inch, and 0.25 inch for line sizes 5 inch and larger.

E. Steam Systems (15 psig And Lower): Y type; cast iron body; stainless steel screens; bolted or threaded screen retainer tapped for a blow off valve; threaded in sizes through 2 inch and rated at not less than 250 psi at 400°F; flanged in sizes over 2 inch and rated at not less than 125 psi at 350°F. Screen to be 20 mesh for line sizes 2 inch and less, 0.050-inch perforations for line sizes over 2 inch.

F. Steam Systems (15 psig to 100 psig): Y type; steel body; stainless steel screens; bolted or threaded screen retainer tapped for a blow off valve; threaded or flanged in sizes through 2 inch; flanged in sizes

over 2 inch; rated at not less than 250 psi at 400°F. Screen perforations to be 0.050 inch for all line sizes.

G. Steam Systems (100 psig to 300 psig): Y type; cast steel or forged steel body; stainless steel screen; bolted or threaded screen retainer tapped for a blow off valve; threaded, socket weld, butt weld, or flanged end connections in all sizes; suitable for steam service at 300 psig and 800 deg F. Screen perforations to be 0.050 inch for all line sizes.

H. Steam Systems (Over 300 psig): It is recommended that the designer should consult with owner for service over 300 PSIG

2.05 AIR VENTS

A. Manual Key Type Vents: Bell and Gossett Model 4V; Eaton/Dole Model 9, 9B, or 14A.
   1. Bronze body with nonferrous internal parts, screwdriver operated, designed to relieve air from the system when vent is opened, rated at not less than 125 psig at 220°F.

B. Manual Ball Valve Vents: Provide 1/4" ball valves for manual venting of air. Reference Section 23 05 23 – General Duty Valves for HVAC.

C. Automatic Vents:
   1. Thrush Model 720, Bell and Gossett Model 107, Watson McDaniel Model AV813W
   2. Cast iron body with nonferrous internal parts, designed to vent air automatically with float principle without allowing air to enter the system, rated at not less than 125 psig at 220°F.

PART 3 - EXECUTION

3.01 GENERAL

A. Install specialties in accordance with manufacturer's instructions to permit intended performance.

3.02 TEST WELLS

A. Install in piping systems as indicated on the drawings and/or details wherever provisions are needed for inserting a thermometer at a later date.

3.03 P/T (PRESSURE/TEMPERATURE) TEST PLUGS

A. Install in piping systems as indicated on the drawings and/or details. Do not insulate over test plugs.

3.04 STRAINERS

A. Install all strainers where indicated on the project details, allowing sufficient space for the screens to be removed. Rotate screen retainer where required by the installation so blowdown can remove accumulated dirt from the strainer body.

B. Water Systems: Install a ball valve for blowdown in the tapped screen retainer; valve to be the same size as the tapping.

C. Steam Systems - Low Pressure (15 psig And Lower): Install a gate valve for blowdown in the tapped screen retainer; valve to be the same size as the tapping, suitable for system pressure (reference section 23 05 23).

D. Steam Systems - High Pressure (Above 15 psig): Install a forged steel gate valve for blowdown in the tapped screen retainer; valve to be the same size as the tapping, suitable for system pressure (reference section 23 05 23).

3.05 AIR VENTS

A. Manual Key Type Vents: Bell and Gossett Model 4V; Eaton/Dole Model 9, 9b, or 14a.
   1. Install at all high points where air may collect and not be carried by the system fluid. Use a soft Type L copper "pigtail" so the vent can be positioned for venting and collecting any water that might escape.

B. Manual Ball Valve Vents: Install at all high points where air may collect and not be carried by the system fluid, on air handling coils, and where indicated elsewhere as shown on drawings and details. Vents included at terminal units are acceptable only where terminal unit is at the high point of the system.

C. Automatic Vents: Install on the top of air separators on systems using bladder type expansion tanks. Install at other locations as indicated on the drawings or details. All locations to have a ball valve installed upstream of the vent for maintenance purposes. Provide vent tubing to nearest drain. Coordinate routing with owner before installation.

END OF SECTION

SECTION 23 05 23
GENERAL DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Base Bid: Unless noted otherwise, Mechanical Contractor shall provide all labor and materials for a complete system in this specification section.

1.02 SECTION INCLUDES

A. This section includes valve specifications for all HVAC systems except where indicated under Related Work. Included are the following topics:
   1. Bypass Valves
   2. Water System Valves
      a. Gate Valves (Hydronic)
      b. Ball Valves (Hydronic)
      c. Butterfly Valves (Hydronic)
      d. Globe Valves (Hydronic)
      e. Swing Check Valves (Hydronic)
      f. Spring Loaded Check Valves (Hydronic)
      g. Balance Valves
      h. Drain Valves (Hydronic)
      i. Self-Contained Control Valves
   3. Stem Extensions

1.03 RELATED WORK

A. Applicable provisions of Division 1 govern work under this section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 15 – Piping Specialties
D. Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC

1.04 SUBMITTALS

A. Refer to Section 23 05 00 – Common Work Results for HVAC. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Bypass Valves
   2. Water System Valves
      a. Gate Valves (Hydronic)
      b. Ball Valves (Hydronic)
      c. Butterfly Valves (Hydronic)
      d. Globe Valves (Hydronic)
      e. Swing Check Valves (Hydronic)
      f. Spring Loaded Check Valves (Hydronic)
      g. Balance Valves
      h. Drain Valves (Hydronic)
      i. Self-Contained Control Valve
   3. Stem Extensions

B. Contractors shall submit a schedule of all valves indicating type of service, dimensions, materials of construction, and pressure/temperature ratings for all valves to be used on the project. Temperature ratings specified are for continuous operation
C. Contractors shall submit critical flow capacity data supplied by the manufacturer for all steam pressure reducing valves. The calculation from the manufacturer shall be the largest obtainable by internal trim change of the reducing valve.

1.05 QUALITY ASSURANCE

A. Refer to Division 1 for equals and substitutions.

1.06 DESIGN CRITERIA

A. Where valves are specified for individual mechanical services (i.e. hot water heating, steam, etc.) all valves shall be of the same manufacturer unless prior written approval is obtained from owner.

1.07 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 – Common Work Results for HVAC.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Anvil, Apollo, Armstrong, Bell & Gossett, Cash-Acme, Dresser Consolidated, Conval, Crane, Anderson Greenwood and Crosby, Danfoss-Flomatic, DeZurik, Durco, Fisher, Grinnell, Griswold, Hammond, Hancock, Hoffman, Jamesbury, Keystone, Kunkle, Leslie, Lunkenheimer/Cincinnati, Metraflex, Milwaukee, Mueller, Newco, Nexus, Nibco, Powell, RP&C, Sarco, Spence, Stockham, Taco, Tasco, Thrush-Amtrol, Vogt, Watts.

B. All valves shall be manufactured in the United States.

C. All valves shall be designed for operation with not less than 125 lbs. working pressure and of a type permitting repacking while under pressure. Rising stems shall be used wherever possible. Provide valves to allow control of all major branches. All valves 2 inches and larger installed 7 feet on centerline or higher above the floor shall have chain operators.

2.02 BYPASS VALVES

A. A bypass globe valve is required on main steam shutoff valves 4 inch and larger on steam pressures greater than 15 psig for supervised warm-up.

2.03 WATER SYSTEM VALVES

A. All water system valves to be rated at not less than 125 psig water working pressure at 240°F unless noted otherwise.

B. GATE VALVES:
   1. 2" and smaller: Use ball valves; gate valves will not be accepted in sizes 2" and smaller.

C. BALL VALVES:
   1. 2" and smaller: Two-piece bronze body; threaded or soldered ends, as appropriate to the pipe material; stainless steel or chrome plated brass/bronze ball; conventional port; glass filled teflon seat; threaded packing gland follower; blowout-proof stem; 600 psig WOG.
   2. Valve stems shall allow operators to clear insulation without interference. Provide stem extensions when valve operators interfere with pipe insulation.
   3. Apollo 70-100/200 series, Hammond 8301/8311, Milwaukee BA100/150, Nibco T/S 585-70, Stockham S206/216.

D. BUTTERFLY VALVES:
   1. 2" and smaller: Use ball valves; butterfly valves will not be accepted in sizes 2 inch and smaller.
   2. Valve stems shall allow operators to clear insulation without interference. Provide stem extensions when valve operators interfere with pipe insulation.
   3. Use threaded lug type valves for installation with class 125/150 flanges.
   4. Centerline series 200, DeZurik BGS II, Keystone Fig. 222, Nibco LD2000 (2-1/2”-12”)/LD1000 (14” and above), Victaulic 300 series (2-1/2”-12”)/709 series (14”-24”).
   5. Provide ten-position lever actuators for valves 3" and smaller. Provide worm gear operators for valves 8" and larger.
   6. Where butterfly valves are indicated or specified to be installed at the location of a flow sensing device, provide the butterfly valves with a memory stop.

E. GLOBE VALVES:
   1. Do not use globe valves for water service, except in temperature control applications.

F. SWING CHECK VALVES:
   1. 2" and smaller: Class 125, bronze body, threaded or soldered ends, re-grindable seat, bronze disc, threaded cap, suitable for installation in a horizontal or vertical line with flow upward.
   2. Crane 137/1342, Hammond IB912/IB940, Lunkenheimer 2144/2145, Milwaukee 509/1509, Nibco T-413-B/S-413-B, Powell 578/1825, Stockham B-309/B-319.
   3. Crane 373, Hammond IR1124, Lunkenheimer 1790, Milwaukee F2974, Nibco F918, Powell 559, Stockham G-931.

G. SPRING LOADED CHECK VALVES:
   1. 2" and smaller: Class 125, bronze body, threaded, solder or wafer ends, bronze trim, stainless steel spring, teflon seat unless only bronze available.
   2. APCO 300 series, ConBraCo 61 series, Mueller 303BP, Nibco T-480-Y/S-480-Y, Val-Matic 1400 series.
   3. APCO 600 series, Metraflex 900 series, Milwaukee 1800 series, Mueller Steam 101M-AP/105M-AP, Nibco F910 series, Val-Matic 1800 series, Victaulic series 716.

H. BALANCE VALVES:
   1. 2" and smaller: Bronze or copper alloy body with calibrated ball, globe or venturi/valve arrangement, integral pointer and calibrated scale to register degree of valve opening, memory stop, drain tapping, threaded or soldered ends, with or without integral unions, P/T or Shraeder pressure taps with integral check valves and seals, adjustable memory stop, protective Yoke, and suitable for 200 psig water working pressure at 250°F.
   2. Armstrong CBV, Bell & Gossett Circuit Setter Plus, Griswold Quickset, Nexus Orturi, Nibco 1710 Series, Taco Accu-Flo, Tour & Anderson STAS/STAD, Victaulic series 786/787, Hays Fluid Controls.
   3. Include one bellows type differential pressure meter kit that includes a six inch diameter gauge with 270° arc readout and having an accuracy of ±1% of full scale or better and suitable for the differential pressures of the valves supplied for this project, over-range protection, color coded hoses not less than ten feet in length with brass connectors suitable for connection to the low and high pressure connections on the balance valves, instrument valving so meter can be vented and drained, pressure and temperature rating at least equal to that of the valves. Provide meter and all accessories in a durable case with carrying handle.
   4. Barton 247A, Midwest 809.

I. DRAIN VALVES:
   1. Use 3/4-inch ball valve with threaded hose adapter except strainer blowdown valves to be the same size as the blowdown connection.
   2. Hose connection caps shall be rated for 150 psig at 180 degrees Fahrenheit.

J. WATER RELIEF VALVES:
   1. Iron or bronze body, direct pressure actuated, teflon seat, stainless steel stem and spring, suitable for 125 psig water working pressure at 240° F and ASME stamped, with Btu capacity and set point as scheduled.
   2. Bell & Gossett, Cash-Acme, Consolidated, Kunkle, Watts.

K. SELF CONTAINED CONTROL VALVES:
   1. Cast bronze or forged brass body, actuator with integral temperature sensor and adjustment-spring balanced bellows, stainless steel spindle riding against an O-ring within the packing gland, O-ring packing gland replaceable while the system is in operation with standard tools and without any need for isolation valves, suitable for 125 psig water working pressure at 240°F. Valves to return to the open position upon failure of temperature control unit.
   2. Bell & Gossett, Danfoss-Flomatic, Taco.

2.05 STEM EXTENSIONS

A. Provide stem extensions when valve operators interfere with pipe insulation.

PART 3 – EXECUTION

3.01 GENERAL

A. Properly align piping before installation of valves in an upright position; operators installed below the valves will not be accepted.

B. Install valves in strict accordance with valve manufacturer's installation recommendations. Do not support weight of piping system on valve ends.

C. Install all temperature control valves.

D. Install all valves with the stem in the upright position. Valves may be installed with the stem in the horizontal position only where space limitations do not allow installation in an upright position or where large valves are provided with chain wheel operators. Where valves 2-1/2" and larger are located more than 12'-0" above mechanical room floors, install valve with stem in the horizontal position and provide a chain wheel operator. Valves installed with the stems down, will not be accepted.

E. Install stem extensions when shipped loose from valve.

F. Prior to flushing of piping systems, place all valves in the full-open position.

3.02 SHUT-OFF VALVES

A. Install shut-off valves on both sides of all equipment, on major piping loops, at each branch take-off from mains, at vertical risers, at strainers, and at each automatic valve for isolation or repair. All shut-off valves shall be located to allow proper access for operation for servicing.

B. WATER SYSTEM:

1. Butterfly valves installed at the location of a flow sensing device are to have a memory stop.

3.03 BALANCING VALVES

A. Provide balancing valves for all equipment, on major piping loops, at vertical risers, at each major branch takeoff, and at the discharge of each pump. Provide balancing valve at all terminal devices. Refer to drawings and details for additional locations.

3.04 CALIBRATED BALANCING VALVES

A. Install where indicated on the drawings and details for balancing of hydronic systems. Retain the shipping container for use as removable insulation.

3.05 DRAIN VALVES

A. Provide drain valves for complete drainage of all systems. Locations of drain valves include low points of piping systems, equipment locations specified, or detailed including reheat coils, other locations required for drainage of systems.

3.06 SPRING LOADED CHECK VALVES

A. Install a spring-loaded check valve in each pump discharge line where two pumps operate in parallel and no combination shutoff, check and balancing valve is being used.

3.07 SWING CHECK VALVES

A. Provide swing check valves where specified, detailed, and at steam condensate lines where they rise at outlet of traps. In such cases, provide isolation valves to allow repair or replacement of check valve.

END OF SECTION

SECTION 23 05 29
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. Base Bid: The Mechanical Contractor shall provide all labor and materials for the hangers and supports for heating equipment and pipe to have a complete system in this specification section. The Mechanical Contractor shall provide all labor and materials for the hangers and supports for ventilating equipment and ductwork to have a complete system in this specification section.

1.02 SECTION INCLUDES

A. This section includes specifications for supports of all HVAC equipment and materials as well as piping system anchors. Included are the following topics:
   1. Pipe Hanger and Support Manufacturers
   2. Structural Supports
   3. Pipe Hangers and Supports
   4. Beam Clamps
   5. Anchors
   6. Roof Mounted Supports
   7. Equipment Curbs
   8. Pipe Penetrations through Roof

1.03 RELATED WORK

A. Applicable provisions of Division 1 shall govern work under this section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 07 00 – HVAC Insulation

1.04 SUBMITTALS

A. Refer to Section 23 05 00 – Common Work Results for HVAC, Submittals. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Pipe Hanger and Support Manufacturers
   2. Structural Supports
   3. Pipe Hangers and Supports
   4. Beam Clamps
   5. Anchors
   6. Roof Mounted Supports
   7. Equipment Curbs
   8. Pipe Penetrations through Roof

B. Schedule of all hanger and support devices indicating shields, attachment methods, and type of device for each pipe size and type of service.
C. All submittals are to comply with submission and content requirements specified in this specification.

1.05 REFERENCE STANDARDS

A. MSS SP-58 Pipe Hangers and Supports - Materials, Design and Manufacture.
B. MSS SP-69 Pipe Hangers and Supports - Selection and Application.

1.06 QUALITY ASSURANCE

A. Refer to Division 1 for equals and substitutions.

1.07 DESIGN CRITERIA

A. Materials and application of pipe hangers and supports shall be in accordance with MSS Standard Practice SP-58 and SP-69 unless noted otherwise.

B. Piping connected to base mounted pumps, compressors, or other rotating or reciprocating equipment is to have vibration isolation supports for a distance of one hundred pipe diameters or three supports away from the equipment, whichever is greater. Standard pipe hangers/supports as specified in this section are required beyond the 100-pipe diameter/3 support distance.
C. Piping flexible connections and vibration isolation supports are required for piping connected to coils that are in a fan assembly where the entire assembly is mounted on vibration supports; the vibration isolation supports are required for a distance of one hundred pipe diameters or three supports away from the equipment, whichever is greater. Piping flexible connection and vibration isolation supports are not required when the fan section is separately and independently isolated by means of vibration supports and duct flexible connections. Standard pipe hangers/supports as specified in this section are required when there are no vibration isolation devices in the piping and beyond the 100-pipe diameter/3 support distance.
D. Piping supported by laying on the bottom chord of joists or trusses will not be accepted.
E. Fasteners depending on soft lead for holding power or requiring powder actuation will not be accepted.
F. Allow sufficient space between adjacent pipes and ducts for insulation, valve operation, routine maintenance, etc.

1.08 DESCRIPTION

A. Provide all supporting devices as required for the installation of mechanical equipment and materials. All supports and installation procedures are to conform to the latest requirements of the ANSI Code for pressure piping.
B. Do not hang any mechanical item directly from a metal deck or run piping so it rests on the bottom chord of any truss or joist.
C. Support apparatus and material under all conditions of operation, variations in installed and operating weight of equipment and piping, to prevent excess stress, and allow for proper expansion and contraction.
D. Protect insulation at all hanger points; see Related Work above.

PART 2 – PRODUCTS

2.01 PIPE HANGER AND SUPPORT MANUFACTURERS

A. Anvil, B-Line, Fee and Mason, Kindorf, Michigan Hanger, Unistrut. Anvil figure numbers are listed below; equivalent material by other manufacturers is acceptable.

2.02 STRUCTURAL SUPPORTS

A. Provide all supporting steel required for the installation of mechanical equipment and materials, whether or not it is specifically indicated or sized, including angles, channels, beams, etc. to suspend or floor support tanks and equipment.

2.03 PIPE HANGERS AND SUPPORTS

A. HANGERS FOR STEEL PIPE SIZES 1/2” THROUGH 2”:
   1. Carbon steel, adjustable, clevis, black finish. Anvil figure 65 or 260.
B. HANGERS FOR STEEL PIPE SIZES 2-1/2” AND OVER:
   1. Carbon steel, adjustable, clevis, black finish. Anvil figure 260.
   2. Adjustable steel yoke cast iron roll, double hanger. Anvil figure 181.
C. MULTIPLE OR TRAPEZE HANGERS:
   1. Steel channels with welded spacers and hanger rods if calculations are submitted.
D. WALL SUPPORT:
   1. Welded steel bracket with hanger. B-Line 3068 Series, Anvil 194 Series.
   2. Perforated epoxy painted finish, 16-12-gauge min., steel channels securely anchored to wall structure with interlocking, split type, bolt secured, galvanized pipe/tubing clamps. B-Line type S channel with B-2000 series clamps, Anvil type AS200 H with AS 1200 clamps. When copper piping is being supported, provide flexible elastomeric/thermoplastic isolation cushion material to completely encircle the piping and avoid contact with the channel or clamp, equal to B-Line

B1999 Vibra Cushion or provide manufacturers clamp and cushion assemblies, B-Line BVT series, Anvil cushion clamp assembly.

E. VERTICAL RISER SUPPORT:
   1. Carbon steel riser clamp, copper plated when used with copper pipe. Anvil figure 261 for steel pipe, figure CT121 for copper pipe.

F. FLOOR SUPPORT FOR PIPE SIZES THROUGH 4":
   1. Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.

G. FLOOR SUPPORT FOR PIPE SIZES 5" AND OVER:
   1. Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.

H. COPPER PIPE SUPPORT:
   1. Carbon steel ring, adjustable, copper plated or polyvinylchloride coated.

I. INSULATION PROTECTION SHIELDS:
   1. Galvanized carbon steel of not less than 18 gauge for use on insulated pipe 2-1/2 inch and larger. Minimum shield length is 12 inches. Equal to Anvil figure 167.

J. STEEL HANGER RODS:
   1. Threaded both ends, threaded one end, or continuous threaded, black finish.
   2. Size rods for individual hangers and trapeze support as indicated in the following schedule.
   3. Total weight of equipment, including valves, fittings, pipe, pipe content, and insulation, are not to exceed the limits indicated.

Maximum Load (Lbs.) (650°F Maximum Temp.)	Rod Diameter (inches)
610	3/8
1130	1/2
1810	5/8
2710	3/4
3770	7/8
4960	1
8000	1-1/4

   4. Provide rods complete with adjusting and lock nuts.

2.05 BEAM CLAMPS

A. MSS SP-69 Type 23 malleable black iron clamp for attachment to beam flange to 0.62 inches thick for single threaded rods of 3/8, 1/2, and 5/8-inch diameter, for use with pipe sizes 4 inch and less. Furnish with a hardened steel cup point set screw. Anvil figure 86.

B. MSS SP-69 Type 28 or Type 29 forged steel jaw type clamp with a tie rod to lock clamp in place, suitable for rod sizes to 1-1/2 inch diameter but limited in application to pipe sizes 8 inch and less without prior approval. Anvil figure 228.

2.06 ANCHORS

A. Use welding steel shapes, plates, and bars to secure piping to the structure.

2.07 ROOF MOUNTED SUPPORTS

A. All weather exposed roof mounted supports shall be constructed of galvanized steel.

B. HEIGHT OF SUPPORTS:
   1. Based on the length of the longest main support member, the height of the support member above the roof deck to be as follows:

Length of Longest Support Member (inches)	Min. Height of Support Above Finished Roof
Up to 36"	18 inches
37" and Over	36 inches

C. SUPPORTS 18" OR LESS IN HEIGHT:
   1. Prefabricated Metal Sleeper Curb:
      a. Constructed of not less than 18 gauge galvanized steel reinforced so it is structurally capable of supporting the intended load with no penetrations through the curb flashing, inside and outside corner sections that are mitered and continuously welded, filled with 3 pound density rigid fiberglass insulation, integral deck mounting flange, nominal two inch wood nail,

galvanized steel counter flashing with metal receiver cap Attach a galvanized steel channel track for securing pipe or duct roller and roller support. Do not use built-in metal base flashings or cants.

2. Wood Build Sleeper Curb:
    a. Constructed of wood blocking anchored to the deck. The curb must be structurally capable of supporting the intended load with no penetrations through the curb flashing. Galvanized steel counter flashing with metal receiver cap. Attach a steel channel track for securing pipe or duct roller support. Do not use built-in metal base flashings or cants.
    b. Use galvanized structural steel members supported by pipe supports and use pipe or duct rollers fastened to the structural member. Pipe supports to be secured to the roof structure and sealed per pipe penetrations through roof specifications as specified in this section.

D. SUPPORTS 36" OR MORE IN HEIGHT:
1. Roof Support Stand/Equipment Roof Support Stand:
    a. Use galvanized structural steel members supported by pipe supports and use pipe or duct rollers fastened to the structural member. Pipe supports to be secured to the roof structure and sealed per pipe penetrations through roof specifications as specified in this section

2.08 EQUIPMENT CURBS

A. Prefabricated Metal Curb:
1. Constructed of not less than 18-gauge galvanized steel reinforced so it is structurally capable of supporting the intended load with no penetrations through the curb flashing, inside and outside corner sections that are mitered and continuously welded, filled with 3-pound density rigid fiberglass insulation, integral deck mounting flange, nominal two-inch wood nailer, galvanized steel counter flashing. Do not use built-in metal base flashings or cants. Use 18-inch-high equipment curbs where the curb surrounds the perimeter of the equipment and there is no roof exposed to the weather.

B. Wood Build Sleeper Curb:
1. Constructed of wood blocking and anchored to the deck. The curb must be structurally capable of supporting the intended load with no penetrations through the curb flashing. Galvanized steel counter flashing. Do not use built-in metal base flashings or cants. Use 18-inch-high equipment curbs where the curb surrounds the perimeter of the equipment and there is no roof exposed to the weather.

2.09 PIPE PENETRATIONS THROUGH ROOF

A. Multiple Pipe Penetrations:
1. Refer to acceptable Equipment Curb types listed above for curb specifications. An 8" high (minimum) curb height is required. The coping cap shall be constructed from laminated acrylic clad thermoplastic (ABS) with graduated step boots to accommodate various size pipes, stainless steel fastening screws for cover, stainless steel band clamps for securing boots around the pipe, and stainless-steel band clamp or mechanical locking seal for securing boots around the ABS coping cap flanges.

B. Single Pipe Penetrations:
1. A stack flashing penetration may be utilized for single pipe penetrations through built up roofs and single ply membrane roofs. Utilize high temperature sealant for all high temperature applications. This includes but is not limited to steam condensate vent piping, steam safety relief piping, and flues.
2. A single pre-manufactured boot may be utilized for single pipe penetrations through single ply membrane roofs only.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install supports to provide for free expansion of the piping and duct system. Support all piping from the structure using concrete inserts, beam clamps, ceiling plates, wall brackets, or floor stands. Fasten

ceiling plates and wall brackets securely to the structure and test to demonstrate the adequacy of the fastening.

B. Piping shall be supported independently from ductwork and all other trades.

C. Where piping can be conveniently grouped to allow the use of trapeze type supports, use standard structural shapes for the supporting steel.

D. Perform all welding in accordance with standards of the American Welding Society. Clean surfaces of loose scale, rust, paint or other foreign matter and properly align before welding. Use wire brush on welds after welding. Welds shall show uniform section, smoothness of weld metal and freedom from porosity and clinkers. Where necessary to achieve smooth connections, joints shall be dressed smooth.

3.02 HANGER AND SUPPORT SPACING

A. Place a hanger within 12 inches of each horizontal elbow, valve, strainer, or similar piping specialty item.

B. Where several pipes can be installed in parallel and at the same elevation, provide multiple or trapeze hangers.

C. Support riser piping independently of connected horizontal piping.

D. Adjust hangers to obtain the slope specified in the piping section of this specification.

E. Space hangers for pipe as follows:

Pipe Material	Pipe Size	Max. Spacing
Steel	1/2" through 1-1/4"	6'-6"
Steel	1-1/2" through 6"	10'-0"
Steel	8" through 12"	14'-0"
Steel	14" and over	20'-0"
Copper	1/2" through 1-1/4"	5'-0"
Copper	1-1/2" and larger	8'-0"
Thermoplastic	All sizes	6'-0" or manufacturer's recommendations, whichever is more stringent

3.03 VERTICAL RISER CLAMPS

A. Support vertical piping with clamps secured to the piping and resting on the building structure or secured to the building structure below at each floor.

3.04 ANCHORS

A. Install where indicated on the drawings and details. Where not specifically indicated, install anchors at ends of principal pipe runs and at intermediate points in pipe runs between expansion loops. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.05 ROOF MOUNTED SUPPORTS

A. Use for all pipe and ductwork on roof. Secure bottom of support flat on roof deck. Apply two coats of zinc rich paint to cut edges of all galvanized steel elements. Flashing and counter flashing by the General Contractor.

3.06 EQUIPMENT CURBS

A. Secure bottom of support flat on roof deck. Secure equipment to curb in accordance with equipment manufacturer's instructions. Flashing and counter flashing by the General Contractor.

B. Fill the entire void space with compressible fiberglass insulation.

3.07 PIPE PENETRATION THROUGH ROOF

A. Install at points where pipes penetrate roof. Install as shown on the drawings, as detailed and according to the manufacturer's installation instructions. Flashing and counterflashing by the General Contractor.

END OF SECTION

SECTION 23 05 93
TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. Contractor provide:
   1. Personnel to accompany and assist Architect/Engineer and air balancer during test, adjust and balancing of piping system(s).
   2. Have the temperature control manufacturer's representative set and adjust automatically operated devices to achieve specified sequence of operations.
   3. Have the temperature control manufacturer's representative accompany and assist Architect/Engineer and Air Balancer during test, adjust and balancing of piping system(s).
   4. The balancing will be performed by a subcontractor retained by the Mechanical Contractor.

B. Work by others:
   1. The balancing will be performed by a subcontractor retained by Dane County.

1.02 SECTION INCLUDES

A. This section includes air and water testing, adjusting and balancing for the entire project. Included are the following topics:
   1. Performing Testing, Adjusting and Balancing
   2. VAV Supply and Exhaust Duct System Static Pressure Setpoint
   3. Hydronic System Differential Pressure Control Setpoint
   4. Hydronic Systems

1.03 RELATED WORK

A. Applicable provisions of the General Conditions, Supplementary General Conditions and General Requirements in Division 1 govern work under this section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 23 – General Duty Valves for HVAC Piping
D. Section 23 07 00 – HVAC Insulation
E. Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC

1.04 SUBMITTALS

A. Refer to Division 1 for submittals. At a minimum, provide submittals for the following items:
   1. Testing, Adjusting and Balancing Report

B. Submit testing, adjusting and balancing reports bearing the seal and signature of the NEBB or AABC Certified Test and Balance Supervisor. The reports certify that the systems have been tested, adjusted and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed and are operating; and are an accurate record of all final quantities measured to establish normal operating values of the systems.

C. Submission: Distribute electronic copies of the Report to the Contractor, the Project Coordinator, Architect/Engineer, and the owner.

D. Format: Cover page identifying project name, project number and descriptive title of contents. Divide the contents of the report into the below listed divisions:
   1. General Information
   2. Summary
   3. Air Systems
   4. Hydronic Systems

E. Contents: Provide the following minimum information, forms and data:
   1. General Information: Inside cover sheet identifying Test and Balance Agency, Contractor, Architect, Engineer, Project Name and Project Number. Include addresses, contact names and telephone numbers. Also include a certification sheet containing the seal and signature of the Test and Balance Supervisor.

2. Summary: Provide summary sheet describing mechanical system deficiencies. Describe objectionable noise or drafts found during testing, adjusting and balancing. Provide recommendations for correcting unsatisfactory performances and indicate whether modifications required are within the scope of the contract, are design related or installation related. List instrumentation used during testing, adjusting and balancing procedures.
3. The remainder of the report to contain the appropriate standard NEBB or AABC forms for each respective item and system. Fill out forms completely. Where information cannot be obtained or is not applicable indicate same.
4. Instruments:
    a. Air balance instruments - Ranges shown are guides. Actual ranges used are subject to Architect/Engineer approval
    b. Velometer with probes and Pitot tube.
    c. Rotating vane anemometer.
    d. ASHRAE Standard Pitot tubes, stainless steel 5/16 outside diameter, lengths 18" and 36".
    e. Magnehelic Differential Air Pressure Gauges, 0 to 0.5", 0 to 1.0" and 0 to 5.0" water pressure ranges, each arranged as a portable unit for use with a standard Pitot tube.
    f. Combination inclined-vertical portable manometer, range 0 to 5.0" water.
    g. Portable type hook gage, range 0 to 12" water.
    h. Portable flexible U-tube manometer, magnetic mounting clips, range 0 to 18" water.
    i. Conical or pyramidal shaped hood.
5. System performance measuring instruments:
    a. Insertion thermometers, with graduations at 0.5° F.
    b. Sling Psychrometer.
    c. Tachometer, Centrifugal Type
    d. Revolution Counter
    e. Clamp-On Volt-Ammeter
    f. Recorders, Portable Type for temperature and humidity.

1.05 FUNCTIONAL TESTS

A. Refer to Section 23 05 00 – Common Work Results for HVAC, Functional Tests. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, perform the following function tests:
    1. Performing Testing, Adjusting and Balancing
    2. VAV Supply and Exhaust Duct System Static Pressure Setpoint
    3. Hydronic System Differential Pressure Control Setpoint
    4. Hydronic Systems

1.06 REFERENCE STANDARDS

A. AABC National Standards for Total System Balance, Sixth Edition, 2002.
B. ASHRAE ASHRAE Handbook, 2007 HVAC Applications, Chapter 37, Testing Adjusting and Balancing.
C. NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems, Seventh Edition, 2005.

1.07 QUALITY ASSURANCE

A. Qualifications:
    1. An independent Firm specializing in the Testing and Balancing of HVAC systems for a minimum of 3 years. A Firm not engaged in the commerce of furnishing or providing equipment or material generally related to HVAC work other than that specifically related to installing Testing and Balancing components necessary for work in this section such as, but not limited to sheaves, pulleys, and balancing dampers.
    2. A certified member of AABC or certified by NEBB in the specific area of work performed. Maintain certification for the entire duration of the project. If certification of firm or any staff performing work is terminated or expires during the duration of the project, contact owner immediately.

3. Technicians on this project must have satisfactorily completed work on a minimum of (3) three projects of at least 50% in size, and of similar complexity. Size is defined as the quantity of each specific individual item requiring testing and balancing such as, but not limited to, equipment, devices, terminal devices, and grilles and diffusers.
4. Submit Qualifications of firm and project staff to the owner upon request.

1.08 DESCRIPTION

A. The Contractor Owner will separately contract with an independent test and balance agency to perform all testing, adjusting, and balancing of air and hydronic systems required for this project. Work related to the testing, adjusting, and balancing that must be performed by the installing mechanical contractor is specified in other section of these specifications.
B. Provide total mechanical systems testing, adjusting and balancing. Requirements include the balance of air and water distribution, adjustment of new and existing systems and equipment to provide design requirements indicated on the drawings, electrical measurement and verification of performance of all mechanical equipment, all in accordance with standards published by AABC or NEBB.
C. Test, adjust and balance all air and hydronic systems so that each room, piece of equipment or terminal device meets the design requirements indicated on the drawings and in the specifications.
D. Accomplish testing, adjusting and balancing work in a timely manner that allows partial occupancy of major buildings, occupancy of one building when the project involves many buildings, and completion of the entire project in the time stated in the Instruction to Bidders and in accordance with the completion schedule established for this project.
E. Verify that provisions are being made to accomplish the specified testing, adjusting and balancing work. If problems are found, handle as specified in Part 3 under Deficiencies.

1.09 JOB CONDITIONS

A. Heating, ventilating, air conditioning equipment shall be completely installed and in continuous operation to accomplish the testing, adjusting and balancing work specified. Complete air balancing prior to hydronic balancing.
B. Perform testing, adjusting and balancing when outside conditions approximate design conditions for heating and cooling functions or when the system is operating at design capacity.
C. The Architect/Engineer and SOS Engineers will be present during testing and balancing to verify that specified procedures are followed (Capitol Complex, Springfield, Illinois only).

1.10 PRE-INSTALLATION MEETING AND SCHEDULING

A. The test and balance agency is required to attend a pre-installation meeting with all other project contractors before the construction process is started. The test and balance agency shall give the Lead Contractor a detailed schedule of testing and balancing tasks for incorporation into the project schedule. Reference General Conditions Division 1 for Lead Contractor responsibilities for scheduling.

1.11 PRE-BALANCE CONFERENCE

A. 90 days prior to beginning testing, adjusting and balancing, schedule and conduct a conference with the owner and the mechanical system and temperature control system installing Contractors. Provide AE and Commissioning Provider (CxP) with a complete copy of the TAB plan for the project. The objective is final coordination and verification of system operation and readiness for testing, adjusting and balancing procedures and scheduling procedures with the above mentioned parties. Indicate work required to be completed prior to testing, adjusting, and balancing and identify the party responsible for completion of that work.

PART 2 – PRODUCTS

2.01 INSTRUMENTATION

A. Provide all required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements to be in accordance with the requirements of NEBB or AABC Standards and instrument manufacturer's specifications.

B. All instruments used for measurements shall be accurate, and calibration histories for each instrument to be available for examination by owner upon request. Calibration and maintenance of all instruments to be in accordance with the requirements of NEBB or AABC Standards.
C. Air balance instruments - Ranges shown are guides. Actual ranges used are subject to Architect/Engineer approval.
   1. Velometer with probes and Pitot tube.
   2. Rotating vane anemometer.
   3. ASHRAE Standard Pitot tubes, stainless steel 5/16 outside diameter, lengths 18" and 36".
   4. Magnehelic Differential Air Pressure Gauges, 0 to 0.5", 0 to 1.0" and 0 to 5.0" water pressure ranges, each arranged as a portable unit for use with a standard Pitot tube.
   5. Combination inclined-vertical portable manometer, range 0 to 5.0" water.
   6. Portable type hook gage, range 0 to 12" water.
   7. Portable flexible U-tube manometer, magnetic mounting clips, range 0 to 18" water.
   8. Conical or pyramidal shaped hood.
D. System performance measuring instruments:
   1. Insertion thermometers, with graduations at 0.5oF.
   2. Sling Psychrometer.
   3. Tachometer, Centrifugal Type
   4. Revolution Counter
   5. Clamp-On Volt-Ammeter
   6. Recorders, Portable Type for temperature and humidity.

PART 3 – EXECUTION

3.01 DAILY REPORTS
A. Submit to owner daily work activity reports for each day on which testing and balancing work is performed. Reports shall include description of day's activities and description of any system deficiencies.

3.02 PRELIMINARY PROCEDURES
A. Review preconstruction meeting report, applicable construction bulletins, applicable change orders and approved shop drawings of equipment, outlets/inlets and temperature controls.
B. Identify and list size, type and manufacturer of all equipment to be tested, including air terminals. Inspect all systems components for proper installation and operation. Use manufacturer's ratings for all equipment to make calculations except where field test shows ratings to be impractical. Verify that all instruments are accurately calibrated and maintained.
C. Check filters for cleanliness, dampers and valves for correct positioning, equipment for proper rotation and belt tension, temperature controls for completion of installation and hydronic systems for proper charge and purging of air.
D. Notify owner on a daily basis during balancing. Identify deficiencies preventing completion of testing, adjusting and balancing procedures. Do not proceed until systems are fully operational with all components necessary for complete testing, adjusting and balancing. Installing Contractors are required to provide personnel to check and verify system completion, readiness for balancing and assist Balancing Agency in providing specified system performance.

3.03 PERFORMING TESTING, ADJUSTING AND BALANCING
A. Perform testing, adjusting and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards except as may be modified below.
B. In areas containing ceilings, remove ceiling tile to accomplish balancing work; replace tile when work is complete and provide new tile for any tile that are damaged by this procedure. If the ceiling construction is such that access panels are required for the work of this section and the panels have not been provided, inform the owner.
C. Cut insulation, ductwork and piping for installation of test probes to the minimum extent necessary for adequate performance of procedures. Patch using materials identical to those removed, maintaining vapor barrier integrity and pressure rating of systems.

D. In air systems employing filters, blank off a sufficient filter area to simulate a pressure drop that is midway between that of a clean filter and that of a dirty filter.
E. Measure and record system measurements at the fan and/or pump to determine total flow. Adjust equipment as required to yield specified total flow at terminals. Proceed taking measurements in mains and branches as required for final terminal balancing. Test and record motor full load amperes and current draw. Test and record system static pressure suction and discharge. Perform terminal balancing to specified flows balancing branch dampers, deflectors, extractors and valves prior to adjustment of terminals.
F. Check and record the following items at each heating and cooling coil:
    1. Inlet water and air temperature.
    2. Leaving water and air temperatures.
    3. Pressure drop of each coil.
    4. Pressure drop across bypass valve.
    5. Pump operating suction and discharge and final total dynamic head.
    6. All mechanical specifications of pumps.
    7. Actual/rated running amperage of pump motor.
G. Measure and record static air pressure conditions across fans, coils and filters. Indicate in report if cooling coil measurements were made on a wet or dry coil and if filter measurements were made on a clean or dirty filter. Spot check static air pressure conditions directly ahead of terminal units.
H. Adjust outside air, return air and relief air dampers for design conditions at both the minimum and maximum settings and record both sets of data. Balance modulating dampers at extreme conditions and record both sets of data. Balance variable air volume systems at maximum air flow rate, full cooling, and minimum flow rate, full heating; record all data.
I. Adjust register, grille and diffuser vanes and accessories to achieve proper air distribution patterns and uniform space temperatures free from objectionable noise and drafts within the capabilities of the installed system.
J. Provide fan and motor drive sheave adjustments necessary to obtain design performance. Provide drive changes specifically noted on drawings, if any. If work of this section indicates that any drive or motor is inadequate for the application, advise the engineer by giving the engineer properly sized motor/drive information (in accordance with manufacturers original service factor and installed motor horsepower requirements); Confirm any change will keep the duct/piping system within its design limitations with respect to speed of the device and pressure classification of the distribution system.
K. Areas or rooms designed to maintain positive, negative or balanced air pressures with respect to adjacent spaces, as indicated by the design air quantities, require special attention. Adjust fan drives, distribution dampers, terminals and controls to maintain indicated pressure relationship.
L. Final air system measurements to be within the following range of specified cfm:
    1. Fans 0% to +10%
    2. Supply grilles, registers, diffusers 0% to +10%
    3. Return/exhaust grilles, registers 0% to -10%
M. Final water system measurements must be within the following range of specified gpm:
    1. Heating flow rates 0% to -10%
N. Contact the temperature control contractor for assistance in operation and adjustment of controls during testing, adjusting and balancing procedures. Cycle controls and verify proper operation and setpoints. Include in report description of temperature control operation and any deficiencies found.
O. Permanently mark equipment settings, including damper and valve positions, control settings, and similar devices allowing settings to be restored. Set and lock memory stops.
P. Leave systems in proper working order, replacing belt guards, closing access doors and electrical boxes, and restoring temperature controls to normal operating settings.
Q. Coordinate and assist commissioning agent with all verification activities defined within this specification including providing all required sampling data necessary for the commissioning process.
R. Verify and record, in the T&B Report, “K” factors for all VAV air terminal devices and air flow stations. Provide minimum of two points of reference for calibration of air flow stations. Points of reference shall include minimum and maximum scheduled airflow quantities.
S. Coordinate air handling unit minimum outside air set points with the Temperature Control Contractor.

3.04 VAV SUPPLY AND EXHAUST DUCT SYSTEM STATIC PRESSURE SET POINT

A. For VAV supply, return and exhaust systems with VAV air terminal devices, determine the minimum required duct static pressure at the DDC static pressure sensor location(s) needed to ensure that all VAV air terminals are operating at their design airflows with the most demanding VAV terminal wide open. Provide these static pressure numbers to the DDC temperature controls contractor and record them in the T&B report for each system.

3.05 HYDRONIC SYSTEM DIFFERENTIAL PRESSURE CONTROL SET POINT

A. For hydronic systems with variable speed pumping, determine the minimum required system differential pressure set point needed to ensure that all terminal devices are operating at their design water flows with the most demanding terminals device control valve wide open. Provide the differential control setting set point to the DDC temperature control contractor and record them in the T&B report for each system.

3.06 HYDRONIC SYSTEMS

A. Complete air balance must have been accomplished before water balance is begun. Open all valves to full position, including pump discharge valves, coil balancing fittings and return line balancing fittings. Close bypass valves.
B. For HVAC pumps 10 horsepower or less, valve throttling alone may be used for hydronic system balancing.
C. Check Pump Rotation.
D. Throttling of triple-duty valves shall not exceed 50% closed. Where additional throttling would be necessary to achieve the system, design flow the impellor shall be trimmed.
E. Verify Triple duty valve utilized on systems with Variable Frequency Drives are 100% open when balancing work is complete.
F. The pressure drops across triple duty valves shall not exceed 25 ft. w.g. Where additional throttling would be necessary to achieve the system, design flow the impellor shall be trimmed.
G. For HVAC pumps greater than 10 horsepower through 60 horsepower, trim the impellor where valve throttling will result in a draw that exceeds 3 horsepower.
H. Future fouling of an open piping system may be considered when determining impellor trim requirements.
I. Check expansion tanks to make sure they are not air bound and that the system is full of water. Check all air vents at high points of water systems to make sure they are installed properly and are operating freely. Make certain all air is removed from circulating system.
J. Verify butterfly valves utilized for hydronic system balancing are provided with position-lock operators (memory stops) in accordance with Section 23 05 23 – General Duty Valves for HVAC Piping. The adjustment and marking of lever-lock operators that use throttling notches will not be accepted. Lock all memory stops so the valves can be reopened to their balanced positions if they are used for isolation purposes.
K. Examine water in system to determine if it has been treated and is clean. Record your findings in report.

3.07 DEFICIENCIES

A. Division 23 00 00 contractor to correct any installation deficiencies found by the test and balance agency that were specified and/or shown on the Contract Documents to be performed as part of that division of work. Test and balance agency will notify the owner and engineer of these items and instructions will be issued to the Division 23 00 00 contractor for correction of the deficient work. All corrective work to be done at no cost to the owner. Retest mechanical systems, equipment, and devices once corrective work is complete as specified.

END OF SECTION

SECTION 23 07 00
HVAC INSULATION

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. Base Bid:
   1. Mechanical Contractor provide:
      a. Duct covering liner for all insulated ductwork.
      b. Duct covering insulation for all supply air ductwork, all outside air, all make-up air, all return air, all relief air, all exhaust air (within 30' of fan inlet and outlet), and all plenum ductwork.
   2. Mechanical Contractor provide insulation for:
      a. Mechanical Hot Water Systems
      b. All new hot water supply, hot water return, and condensate piping that has had insulation removed will be reinsulated according to this section and rejacketed.

1.02 SECTION INCLUDES

A. This section includes insulation specifications for heating, ventilating and air conditioning piping, ductwork and equipment. Included are the following topics:
   1. Insulation Types
      a. Flexible Fiberglass Insulation
      b. Rigid Fiberglass Insulation
      c. Semi-Rigid Fiberglass Insulation
      d. Calcium Silicate Insulation
      e. Elastomeric Insulation
      f. Polyolefin Insulation
      g. Phenolic Insulation
      h. Extruded Polystyrene Insulation
      i. Polyisocyanurate Insulation
      j. Cellular Glass Insulation
      k. Mineral Wool Insulation
      l. Fireproofing Insulation
      m. Fire-Stop Insulation
      n. Duct Liner Insulation
   2. Metal Covering and Jackets
      a. PVC Fitting Covers And Jackets (PFJ)
      b. All Service Jackets (ASJ)
      c. Foil Scrim All Service Jackets (FSJ)
      d. Protective Metal Jackets (PMJ)
      e. Self-Adhering Jackets (SAJ)
      f. Fabric Reinforced Mastic Jackets (FMJ)
      g. Vapor Retarding Jackets (VRJ)
      h. Vapor Retarding Tape
   3. Insulation Inserts and Pipe Shields
   4. Expansion Joint and Valve Insulation Blankets
   5. Accessories

1.03 RELATED WORK

A. Applicable provisions of Division 1 govern work under this section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 15 – Piping Specialties
D. Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment
E. Section 23 21 13 – Hydronic Piping
F. Section 23 23 00 – Refrigerant Piping
G. Section 23 31 00 – HVAC Ducts and Casings

1.04 SUBMITTALS

A. Refer to Division 1 for submittals. At a minimum, provide submittals for the following items:
   1. Insulation Types
      a. Flexible Fiberglass Insulation
      b. Rigid Fiberglass Insulation
      c. Semi-Rigid Fiberglass Insulation
      d. Calcium Silicate Insulation
      e. Elastomeric Insulation
      f. Polyolefin Insulation
      g. Phenolic Insulation
      h. Extruded Polystyrene Insulation
      i. Polyisocyanurate Insulation
      j. Cellular Glass Insulation
      k. Mineral Wool Insulation
      l. Fireproofing Insulation
      m. Fire-Stop Insulation
      n. Duct Liner Insulation
      o. Fluid-Applied Ductwork Insulation (FDI)
   2. Metal Covering and Jackets
      a. PVC Fitting Covers And Jackets (PFJ)
      b. All Service Jackets (ASJ)
      c. Foil Scrim All Service Jackets (FSJ)
      d. Protective Metal Jackets (PMJ)
      e. Self-Adhering Jackets (SAJ)
      f. Fabric Reinforced Mastic Jackets (FMJ)
      g. Vapor Retarding Jackets (VRJ)
      h. Vapor Retarding Tape
   3. Insulation Inserts and Pipe Shields
   4. Expansion Joint and Valve Insulation Blankets
   5. Accessories

B. Submit a schedule of all insulating materials to be used on the project, including adhesives, fastening methods, fitting materials along with material safety data sheets and intended use of each material. Include manufacturer's technical data sheets indicating density, thermal characteristics, jacket type, and manufacturer's installation instructions.

1.05 REFERENCE STANDARDS

A. ASTM B209 Aluminum and Aluminum Alloy Sheet and Plate
B. ASTM C165 Test Method for Compressive Properties of Thermal Insulations
C. ASTM C177 Heat Flux and Thermal Transmission Properties
D. ASTM C195 Mineral Fiber Thermal Insulation Cement
E. ASTM C240 Cellular Glass Insulation Block
F. ASTM C302 Density of Preformed Pipe Insulation
G. ASTM C303 Density of Preformed Block Insulation
H. ASTM C355 Test Methods for Test for Water Vapor Transmission of Thick Materials
I. ASTM C449 Mineral Fiber Hydraulic Setting Thermal Insulation Cement
J. ASTM C518 Heat Flux and Thermal Transmission Properties
K. ASTM C533 Calcium Silicate Block and Pipe Thermal Insulation
L. ASTM C534 Preformed Flexible Elastomeric Thermal Insulation
M. ASTM C547 Mineral Fiber Preformed Pipe Insulation
N. ASTM C552 Cellular Glass Block and Pipe Thermal Insulation
O. ASTM C553 Mineral Fiber Blanket and Felt Insulation
P. ASTM C578 Preformed, Block Type Cellular Polystyrene Thermal Insulation
Q. ASTM C591 Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
R. ASTM C610 Expanded Perlite Block and Thermal Pipe Insulation
S. ASTM C612 Mineral Fiber Block and Board Thermal Insulation
T. ASTM C921 Properties of Jacketing Materials for Thermal Insulation

U. ASTM C1136 Flexible Low Permeance Vapor Retarders for Thermal Insulation
V. ASTM D412 Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
W. ASTM D1000 Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
X. ASTM D1621 Standard Test Method for Compressive Properties Of Rigid Cellular Plastics
Y. ASTM D1622 Standard Test Method for Apparent Density of Rigid Cellular Plastics
Z. ASTM D1940 Method of Test for Porosity of Rigid Cellular Plastics
AA. ASTM D2126 Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging
BB. ASTM D2240 Standard Test Method for Rubber Property—Durometer Hardness
CC. ASTM E84 Surface Burning Characteristics of Building Materials
DD. ASTM E814 Standard Test Method for Fire Tests of Penetration Firestop Systems
EE. ASTM E2336 Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems
FF. MICA National Commercial & Industrial Insulation Standards
GG. NFPA 225 Surface Burning Characteristics of Building Materials
HH. UL 723 Surface Burning Characteristics of Building Materials

1.06 QUALITY ASSURANCE

A. Refer to Division 1 equals and substitutions
B. Label all insulating products delivered to the construction site with the manufacturer's name and description of materials.
C. Insulation systems shall be applied by experienced contractors. Within the past five (5) years, the contractor shall be able to document the successful completion of a minimum of three (3) projects of at least 50% of the size and similar scope of the work specified in this section.
B. Fluid-applied ductwork insulation is a roofing product that shall be applied only by qualified contractors. Contractor shall be recognized by the manufacturer of the Polyurea 2-part liquid membrane system as an “approved” or “authorized” applicator. Only manufacturer recognized, qualified and authorized Contractor’s who’s labor and material are fully covered, without exception, by the manufacturer’s warranty, as required by this section, will be allowed to perform the work. Manufacturer must submit letterhead document verifying the Contractor as an authorized applicator of their product and able to receive the specified warranty.

1.07 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 – Common Work Results for HVAC.

1.08 DESCRIPTION

A. Furnish and install all insulating materials and accessories as specified or as required for a complete installation. The following types of insulation are specified in this section:
   1. Pipe Insulation
   2. Duct Insulation
   3. Equipment Insulation
B. Install all insulation in accordance with the latest edition of MICA (Midwest Insulation Contractors Association) Standard and manufacturer's installation instructions. Exceptions to these standards will only be accepted where specifically modified in these specifications, or where prior written approval has been obtained from the Owner.

1.09 DEFINITIONS

A. Concealed: shafts, furred spaces, space above finished ceilings, utility tunnels and crawl spaces. All other areas, including walk-through tunnels, shall be considered as exposed.

1.10 ENVIRONMENTAL REQUIREMENTS

A. Do not store insulation materials on grade or where they are at risk of becoming wet. Do not install insulation products that have been exposed to water.
B. Protect installed insulation work with plastic sheeting to prevent water damage.
C. Delivery, Storage And Handling:

1. Deliver field applied material to site in factory fabricated containers with manufacturer's stamp or label showing fire hazard rating of products.
2. Store in original wrappings and protect from weather and construction traffic.
3. Protect against dirt, water, chemical and mechanical damage.
4. Remove damaged insulation from project site, do not install.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Manufacturers: Armacell, Certainteed, Manson, Childers, Dow, Extol, Fibrex, Halstead, H.B. Fuller, Imcoa, Johns Manville, Knauf, Owens-Corning, Partek, Pittsburgh Corning, Rubatex, VentureTape.

B. Materials or accessories containing asbestos will not be accepted.

C. Use composite insulation systems (insulation, jackets, sealants, mastics, and adhesives) that have a flame spread rating of 25 or less and smoke developed rating of 50 or less when tested in accordance with ASTM E84, NFPA 255 or UL 723, with the following exceptions:

D. Pipe insulation which is not located in an air plenum may have a flame spread rating not over 25 and a smoke developed rating no higher than 450 when tested in accordance with UL 723 and ASTM E84.

2.02 INSULATION TYPES

A. Insulating materials shall be fire retardant, moisture and mildew resistant, and vermin proof. Insulation shall be suitable to receive jackets, adhesives and coatings as indicated.

B. Flexible Fiberglass Insulation: Minimum nominal density of 0.75 lbs. per cu. ft., and thermal conductivity of not more than 0.3 at 75 degrees F, rated for service to 250 degrees F.

C. Rigid Fiberglass Insulation: Minimum nominal density of 3 lbs. per cu. ft., and thermal conductivity of not more than 0.23 at 75 degrees F, minimum compressive strength of 25 PSF at 10% deformation, rated for service to 450 degrees F.

D. Semi-Rigid Fiberglass Insulation: Minimum nominal density of 3 lbs. per cu. ft., thermal conductivity of not more than 0.28 at 75 degrees F, minimum compressive strength of 125 PSF at 10% deformation, rated for service to 450 degrees F. Insulation fibers perpendicular to jacket and scored for wrapping cylindrical surfaces.

E. Calcium Silicate Insulation: Rigid hydrous calcium silicate, ASTM C533, Type I, minimum dry density of 12.5 lbs. per cu. ft., thermal conductivity of not more than 0.44 at 300 degrees F, maximum water absorption of 90% by volume, minimum compressive strength 140 psi at 5% deformation, rated for service range of 0 degrees F to 1,200 degrees F,. Material to be visually coded or marked to indicate it is asbestos free.

F. Elastomeric Insulation: Flexible closed cell, minimum nominal density of 5.5 lbs. per cu. ft., thermal conductivity of not more than 0.27 at 75 degrees F, minimum compressive strength of 4.5 psi at 25% deformation, maximum water vapor permeability of 0.17 perm inch, maximum water absorption of 6% by weight, rated for service range of -20 degrees F to 220 degrees F on piping and 180 degrees F where adhered to equipment.

G. Polyolefin Insulation: Flexible closed cell, minimum nominal density of 1.5 lbs. per cu. ft., thermal conductivity of not more than 0.24 at 75 degrees F, minimum compressive strength of 5 psi at 25% deformation, maximum water vapor permeability of 0.0 perm inch, maximum water absorption of 0% by weight and volume, rated for service range of -165 degrees F to 210 degrees F.

H. Phenolic Insulation: Rigid closed cell, minimum nominal density of 2.2 lbs. per cu. ft., thermal conductivity of not more than 0.13 at 75 degrees F, minimum compressive strength of 31 psi parallel and 18 psi perpendicular, maximum water vapor permeability 0.117 perm inch, maximum water absorption of .5% by volume, rated for service range of -290 degrees F to 250 degrees F.

I. Extruded Polystyrene Insulation: Rigid closed cell, minimum nominal density of 1.6 lbs. per cu. ft., thermal conductivity of not more than 0.285 at 75 degrees F, minimum compressive strength of 20 psi, maximum water vapor permeability of 1.5 perm inch, maximum water absorption of .5 % by volume, rated for service range of -290 degrees F to 165 degrees F.

J. Polyisocyanurate Insulation: Rigid closed cell polyisocyanurate, minimum nominal density of 2.0 lbs. per cu. ft., thermal conductivity of not more than 0.19 at 75 degrees F aged 180 days, minimum compressive strength of 24 psi parallel and 13 psi perpendicular, maximum water vapor permeability

of 4 perm inch, maximum water absorption of 2% by volume, rated for service range of -290 degrees F to 300 degrees F.

K. Cellular Glass Insulation: Rigid closed cell, minimum nominal density of 8.5 lbs. per cu. ft., thermal conductivity of not more than 0.36 at 50 degrees F, minimum compressive strength of 100 psi, maximum water vapor permeability of 0.0 perm inch, maximum water absorption of .2% by volume, rated for service range of -450 degrees F to 900 degrees F.

L. Duct Liner Insulation:
1. Semi-rigid glass fiber blanket, 1 inch thick, 1.5 lbs./cu/ft. density, K value of 0.25 at 75 degrees F.
2. Facing: NFPA 90A and 90B, fire resistant anti-bacterial neoprene coating or coating shall not allow moisture penetration into insulation.
3. Temperature Range: 35 degrees F. to 180 degrees F.
4. Air Velocity: Up to 4000 ft./min.
5. Minimum Sound Absorption:

Frequency	1 inch
125	.26
250	.48
500	.70
1000	.90
2000	.93
4000	.80

Frequency	1 inch	1-1/2 inch	2 inch
Minimum NRC:	.70	.85	.95

6. Fire Hazard Classification: 25 maximum flame spread; 25 maximum fuel contributed; 50 maximum smoke developed.
7. Manufacturers:
   a. Knauf: Duct Liner M
   b. Schuller Linacoustic HP
   c. Owens-Corning Fiberglas: Aeroflex Duct Liner
8. Accessories:
   a. Provide mechanical fasteners and similar accessories recommended by insulation manufacturer for applications indicated.
   b. Provide cements, waterproof adhesives, coatings, sealers, protective finishes and similar compounds recommended by insulation manufacturer to meet fire ratings and for applications indicated.

2.03 JACKETS

A. PVC Fitting Covers And Jackets (PFJ):
1. White PVC film, gloss finish one side, semi-gloss other side, FS LP-535D, Composition A, Type II, Grade GU. Ultraviolet inhibited indoor/outdoor grade to be used where exposed to high humidity, ultraviolet radiation, in kitchens or food processing areas or installed outdoors. Jacket thickness to be minimum .03" for piping 12" and smaller, .04" for piping 15" and larger.

B. All Service Jackets (ASJ): Heavy duty, fire retardant material with white kraft reinforced foil vapor barrier, factory applied to insulation with a self-sealing pressure sensitive adhesive lap, maximum permeance of .02 perms and minimum beach puncture resistance of 50 units.

C. Foil Scrim All Service Jackets (FSJ): Glass fiber reinforced foil kraft laminate, factory applied to insulation. Maximum permeance of .02 perms and minimum beach puncture resistance of 25 units.

D. Protective Metal Jackets (PMJ): .016 inch thick pebble finish aluminum or .010 inch thick stainless steel with safety edge.

E. Self-Adhering Jackets (SAJ):
1. 5-ply, self-adhering multiple laminated waterproofing material with reflective aluminum foil, high density polymer films and cold weather acrylic adhesive providing zero (0.0) permeability. Minimum 6 mils material thickness, 35lb puncture resistance when tested in accordance with

ASTM D1000 and flame spread/smoke developed rating of 10/20 when tested in accordance with UL 723.

2. Vapor retarding tape shall be specifically designed and manufactured for use with the self-adhering jacket specified above. Tape shall be provided by the same manufacturer that provides jacketing. Vapor retarding tapes used with self-adhering jackets shall have a maximum permeance of 0.0 perms.

F. Fabric Reinforced Mastic Jackets (FMJ): Glass fiber reinforcing fabric imbedded in weather barrier mastic as per manufacturer's recommended procedure for 2 coat application.

G. Vapor Retarding Jackets (VRJ): Polyvinylidene chloride (PVDC) vapor retarding jacket material with minimum 6 mils material thickness and maximum permeance of 0.01 perms. Material shall not support the growth of mold or mildew. Dow Saran or equivalent.

H. Vapor Retarding Tape: Vapor retarding tape shall be specifically designed and manufactured for use with the vapor retarding jacket specified above. Tape shall be provided by the same manufacturer that provides jacketing. Vapor retarding tapes used with vapor retarding jackets shall have a maximum permeance of 0.01 perms.

2.04 INSULATION INSERTS AND PIPE SHIELDS

A. Manufacturers: B-Line, Pipe Shields, Value Engineered Products

B. Construct inserts with calcium silicate or polyisocyanurate (service temperatures below 300 degrees F only), minimum 140 psi compressive strength. Piping 12" and larger, supplement with high density 600 psi structural calcium silicate insert. Provide galvanized steel shield. Insert and shield to be minimum 180 degree coverage on bottom supported piping and full 360 degree coverage on clamped piping. On roller mounted piping and piping designed to slide on support, provide additional load distribution steel plate.

C. Where contractor proposes shop/site fabricated inserts and shields, submit schedule of materials, thicknesses, gauges and lengths for each pipe size to demonstrate equivalency to pre-engineered/premanufactured product described above. On low temperature systems, high density rigid polyisocyanurate may be substituted for calcium silicate provided insert and shield length and shield gauge are increased to compensate for lower insulation compressive strength.

D. Calcium Silicate Insulation: Rigid hydrous calcium silicate, ASTM C533, Type I, minimum dry density of 12.5 lbs. per cu. ft., thermal conductivity of not more than 0.44 at 300 degrees F, maximum water absorption of 90% by volume, minimum compressive strength 140 psi at 5% deformation, rated for service range of 0 degrees F to 1,200 degrees F,. Material to be visually coded or marked to indicate it is asbestos free.

E. Polyisocyanurate Insulation: Rigid closed cell polyisocyanurate, minimum nominal density of 2.0 lbs. per cu. ft., thermal conductivity of not more than 0.19 at 75 degrees F aged 180 days, minimum compressive strength of 24 psi parallel and 13 psi perpendicular, maximum water vapor permeability of 4 perm inch, maximum water absorption of 2% by volume, rated for service range of -290 degrees F to 300 degrees F.

F. Pre-compressed 20# density molded fiberglass blocks, Hamfab or equal, of the same thickness as adjacent insulation may be substituted for calcium silicate inserts with one 1"x6" block for piping through 2-1/2" and three 1"x6" blocks for piping through 4". Submit shield schedule to demonstrate equivalency to pre-engineered/premanufactured product described above.

G. Wood blocks will not be accepted.

2.05 EXPANSION JOINT AND VALVE INSULATION BLANKETS

A. Manufacturers: Advance Thermal Corporation, TANI Division B.D. Schiffler, Universal Insulation Products.

B. Jacket shall be 7 ounce per square yard Teflon coated Nomex fabric which is designed for wet and dry steam applications to 550ºF. Equal to Advance Thermal Corp. Steamguard-1 cloth. The covers shall be installed to shed water and have a 1-inch rain flap.

C. All seams shall be sewn twice with double locked stitching. One seam shall be sewn with 3-ply Nomex and the other with 3-ply stainless steel. Hog rings and staples shall not be used.

D. The insulation shall be a 2-inch thick, 6 lb. density ceramic fiber which is held in place with 12 gauge stainless quilt pins which do not puncture the inner surface of the cover.

E. Covers shall be designed to allow access to the expansion and ball joints packing cylinder plungers for repacking with removing the covers.
F. Adjacent pipe insulation must be installed to allow the piping to expand into expansion joints without damaging the insulation or removable covers.

2.06 ACCESSORIES

A. All products shall be compatible with surfaces and materials on which they are applied, and be suitable for use at operating temperatures of the systems to which they are applied.
B. Adhesives, sealants, and protective finishes shall be as recommended by insulation manufacturer for applications specified.
C. Insulation bands to be 3/4 inch wide, constructed of aluminum or stainless steel. Minimum thickness to be .015 inch for aluminum and .010 inch for stainless steel.
D. Tack fasteners to be stainless steel ring grooved shank tacks.
E. Staples to be clinch style.
F. Insulating cement to be ANSI/ASTM C195, hydraulic setting mineral wool.
G. Finishing cement to be ASTM C449.
H. Fibrous glass or canvas fabric reinforcing shall have a minimum untreated weight of 6 oz./sq. yd.
I. Bedding compounds to be non-shrinking and permanently flexible.
J. Vapor barrier coatings to have maximum applied water vapor permeance of .05 perms.
K. Fungicidal water base coating (Foster 40-20 or equal) to be compatible with vapor barrier coating.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that all piping, equipment, and ductwork are tested and approved prior to installing insulation. Do not insulate systems until testing and inspection procedures are completed.
B. Verify that all surfaces are clean, dry and without foreign material before applying insulation materials.

3.02 INSTALLATION

A. All materials shall be installed by skilled labor regularly engaged in this type of work. All materials shall be installed in strict accordance with manufacturer's recommendations, building codes, and industry standards. Do not install products when the ambient temperature or conditions are not consistent with the manufacturer's recommendations. Surfaces to be insulated must be clean and dry. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics and insulation cements. Maintain temperature during and after installation for minimum period of 24 hours.
B. Locate insulation and cover seams in the least visible location. All surface finishes shall be extended in such a manner as to protect all raw edges, ends and surfaces of insulation.
C. Install insulation with smooth and even surfaces. Poorly fitted joints or use of filler in voids will not be accepted. Provide neatly beveled and coated terminations at all nameplates, uninsulated fittings, or at other locations where insulation terminates.
D. Install fabric reinforcing without wrinkles. Overlap seams a minimum of 2 inches.
E. Use full length material (as delivered from manufacturer) wherever possible. Scrap piecing of insulation or pieces cut undersize and stretched to fit will not be accepted.
F. Existing or new insulation damaged and/or removed by the Contractor during remodeling work shall be repaired or replaced with new insulation as directed by the Owner.
G. All pipe and duct insulation shall be continuous through walls, ceiling or floor openings and through sleeves except where firestop or firesafing materials are required. Vapor barriers shall be maintained continuous through all penetrations.
H. Provide a continuous unbroken moisture vapor barrier on insulation applied to systems noted below. Attachments to cold surfaces shall be insulated and vapor sealed to prevent condensation.
I. Provide a complete vapor barrier for insulation on the following systems:
    1. Refrigerant
    2. Insulated Duct
    3. Equipment, ductwork or piping with a surface temperature below 65 degrees F

3.03 PROTECTIVE JACKET INSTALLATION

A. Self-Adhering Jackets (SAJ):
   1. Install according to manufacturer's recommendations. Cut allowing minimum 4" overlap on ends and 6" on longitudinal joints. Align parallel to surface. Remove release paper and press flat to surface to avoid wrinkles. Rub entire surface for full adhesion and sealing at joint overlaps. On exterior applications, provide a bead of compatible caulk along exposed edges.
   2. Piping with self-adhering (SAJ) jackets shall have elbows, fittings, valves and butt joints wrapped with 2 layers of vapor retarding tape. Piping with a PVC jacket (PFJ) installed over the self-adhering (SAJ) jacket may be provided with a single, lapped layer of vapor retarding tape for elbows, fittings and valves under the PVC jacket. Vapor retarding tape shall be compatible with the jacket material used.

B. Vapor Retarding Jackets (VRJ): Piping with vapor retarding (VRJ) jackets shall have elbows, fittings, valves and butt joints wrapped with 2 layers of vapor retarding tape. Piping with a PVC jacket (PFJ) installed over the vapor retarding (VRJ) jackets may be provided with a single, lapped layer of vapor retarding tape for elbows, fittings and valves under the PVC jacket. Vapor retarding tape shall be compatible with the jacket material used.

C. PVC Fitting Covers And Jackets (PFJ): Lap seams and joints a minimum of 2 inches and continuously seal PVC with welding solvent recommended by jacket manufacturer. Lap slip joint ends 4" without fasteners where required to absorb expansion and contraction. For sections where vapor barrier is not required and jacket requires routine removal, tack fasteners may be used. Secure PVC fitting covers with tack fasteners. For systems requiring a vapor barrier, apply a 1-1/2" band of mastic over ends, throat, seams and penetrations.

D. Protective Metal Jacket (PMJ): Lap seams a minimum of 2 inches. Secure with metal bands for end to end joints, and rivets or sheet metal screws for longitudinal joints. Rivets, screws, and bands to be constructed of the same material as the jacket. Locate seams on bottom for exterior applications.

E. Fabric Reinforced Mastic Jackets (FMJ): Glass fiber fabric shall be fitted without wrinkles. Glass fiber fabric shall be sized immediately upon application with lagging adhesive and shall be capable of drying within 6 hrs. Apply adhesive and coating in accordance with manufacturer's recommendations. All seams shall overlap not less than 2".

3.04 PIPING, VALVE AND FITTING INSULATION

A. General:
   1. Install insulation with butt joints and longitudinal seams closed tightly. Provide minimum 2" lap on jacket seams and 2" tape on butt joints, firmly cemented with lap adhesive unless otherwise noted. Additionally secure with staples along seams and butt joints. Coat staples, longitudinal and transverse seams with vapor barrier mastic on systems requiring vapor barrier.
   2. Install insulation continuous through pipe hangers and supports with hangers and supports on the exterior of insulation. Where a vapor barrier is not required or where roller hangers are not being used, hangers and supports may be attached directly to piping with insulation completely covering hanger or support and jacket sealed at support rod penetration. Where riser clamps are required to be attached directly to piping requiring vapor barrier, extend insulation and vapor barrier jacketing/coating around riser clamp.
   3. Where insulated piping is installed on hangers and supports, the insulation shall be installed continuous through the hangers and supports. High density inserts shall be provided as required to prevent the weight of the piping from crushing the insulation. Pipe shields are required at all support locations. The insulation shall not be notched or cut to accommodate the supporting channels.

B. Fully insulate all reheat coil piping, fittings and valves (with the exception of unions) up to coil connection to prevent condensation when coil is inactive during cooling season. Provide a vapor proof seal between the pipe insulation and the insulated coil casing.

C. Insulation Inserts And Pipe Shields:
   1. Provide pipe shields at all hanger and support locations. Rigid insulation inserts shall be installed between the pipe and the insulation shields. Quantity and placement of inserts shall be according to the manufacturer's installation instructions, however the inserts shall be no less than 12" in length. Inserts shall be of equal thickness to the adjacent insulation and shall be vapor sealed as required for system.

2. Provide insulation inserts and pipe shields at all hanger and support locations. Inserts may be omitted on 3/4" and smaller copper piping provided 12" long 22 gauge pipe shields are used.

D. Fittings And Valves: Fittings, valves, unions, flanges, couplings and specialties may be insulated with factory molded or built up insulation of the same thickness as adjoining insulation. Where the ambient temperature exceeds 150 degrees F, cover insulation with fabric reinforcing and mastic. Where the ambient temperatures do not exceed 150 degrees, furnish and install PVC fitting covers.

E. Mineral Fiber: Secure each 3' section with three stainless steel bands or five 16 gauge stainless steel or annealed copper tie wires evenly spaced and at ends. Twist wire ends, snip off excess and turn ends over into insulation. Stagger joints where more than one layer is used.

F. Elastomeric And Polyolefin: Where practical, slip insulation on piping during pipe installation when pipe ends are open. Miter cut fittings allowing sufficient length to prevent stretching. Completely seal seams and joints for vapor tight installation. For elastomeric insulation, apply full bed of adhesive to both surfaces. For polyeolefin, seal factory preglued seams with roller and field seams and joints with full bed of hot melt polyolefin glue to both surfaces. Cover elastomeric insulation on systems operating below 40 degrees F with vapor barrier mastic.

G. Extruded Polystyrene And Polyisocyanurate:

1. Fittings, valves, unions, flanges, couplings and specialties shall be insulated with factory molded insulation of the same thickness as adjoining insulation. Secure insulation sections with two wraps of nylon filament tape 9"-12" on center. On single insulation layer systems and on the outer layer of double insulation layer systems, apply a thin coat of elastomeric joint sealant rated for system operating temperatures to all longitudinal and butt insulation joints covering entire face of joint. Allow sealant to fully cure before applying protective covering. For piping service below 0°F, use two layers of insulation with inner and outer butt and longitudinal joints staggered and offset 90 degrees. Where two layers of insulation are used, do not use sealant on the inner layer or adhere the inner layer to the outer layer. Apply vapor stop bead of joint sealant between pipe and insulation on both sides of valves, expansion/contraction joints, flanges, thermometers/gauges, attached vent and drain lines. Insulate attached non-circulated lines, control lines, vents, etc. for a minimum distance of 6" from pipe. Cover insulation with a protective jacket as specified below. Do not penetrate protective covering or insulation with mechanical fasteners.

3.05 PIPING PROTECTIVE JACKETS

A. In addition to the jackets specified in the pipe insulation schedule below the following protective jackets are required:

1. Provide a protective PVC jacket (PFJ) for the following insulated piping:
   a. Chilled water piping and valves in walk-thru tunnels and valve pits
   b. Exposed piping in kitchens
   c. Piping exposed in finished locations
2. Provide a protective PVC (PFJ) or Fabric Reinforced Mastic (FMJ) jacket for the following insulated piping: All piping within mechanical rooms
3. Provide a protective metal (PMJ) or self-adhering (SAJ) jacket for the following insulated piping:
   a. Exterior installed refrigeration piping
   b. Exposed chilled water, hot water low ambient condenser water, steam, and condensate piping
4. Provide a protective metal jacket (PMJ) for the following insulated piping: Steam and pumped condensate piping and fittings located in walk-thru tunnels and steam pits
5. Provide a protective covering of 2 coats of vapor barrier mastic with fibrous glass or canvas fabric reinforcing (FMJ) for the following insulated piping:
6. Provide a protective self-adhering (SAJ) jacket for the following insulated piping:

3.06 PIPE INSULATION SCHEDULE

A. Provide insulation on new and existing remodeled piping as indicated in the following schedule:

Service	**Insulation**	**Jacket**	**Insulation Thickness by Pipe Size**				
			≤ 1¼"	**1½"**	**2" to <4"**	**4" to 6"**	**8" and larger**
Heating Hot Water	Rigid Fiberglass	ASJ	1.5"	1.5"	2"	2"	2"

Note: On 1" or smaller hot water pipe runouts to terminal unit coils the insulation thickness may be reduced to ½" on both the supply and return pipes within 4ft of the coil but not on the distribution system side of the temperature control valve.

Refrigerant Suction							
>40°F	Elast./Polyol	None	0.5"	1"	1.5"	1.5"	1.5"
40°F to 20°F	Elast./Polyol	None	1"	1.5"	1.5"	1.5"	1.5"
20°F to -20°F	Ext Poly/Polyiso	VRJ or SAJ	1.5"	2"	2"	2"	2.5"
-20°F to -60°F	Ext Poly/Polyiso	VRJ or SAJ	2"	2"	2.5"	2.5"	3"
Makeup Water	Polyiso./Polysty.	VRJ or SAJ	1.5"	1.5"	1.5"	1.5"	1.5"
Low Ambient							

B. The following piping and fittings are not to be insulated:
   1. Hot water piping inside radiation, convector, or cabinet heater enclosures
   2. Piping unions for systems not requiring a vapor barrier
C. For systems with fluid temperatures 65° F or less, furnish and install removable elastomeric insulation covers, plugs or caps for all mechanical equipment and devices that require access by balancing contractors or service and maintenance personnel. Examples include but are not limited to: flow sensing devices, circuit setters, manual ball valve air vents, drain valves, blowdown valves, pressure/temperature test plugs, grease fittings, pump bearing caps, equipment labels, etc. Covers shall be tight fitting to ensure a complete vapor barrier.
D. Provide insulation blanks for all slip type expansion joints, steam pressure reducing valves and boiler stop/check valves. Install per manufacturer's recommendations.
E. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints and valves with insulation of like material and thickness as adjoining pipe and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping. Provide two coats of UV resistant finish for flexible elastomeric cellular insulation without jacketing.

3.07 DUCT INSULATION

A. General:
   1. Secure flexible duct insulation on sides and bottom of ductwork over 24" wide and all rigid duct insulation with weld pins. Space fasteners 18" on center or less as required to prevent sagging.
   2. Secure rigid board insulation to ductwork with weld pins. Apply insulation with joints firmly butted as close as possible to the equipment surface. Pins shall be located a maximum of 3" from each edge and spaced no greater than 12" on center.
   3. Install weld pins without damage to the interior galvanized surface of the duct. Clip pins back to washer and cover penetrations with tape of same material as jacket. Firmly butt seams and joints and cover with 4" tape of same material as jacket. Seal tape with plastic applicator and secure with staples. All joints, seams, edges and penetrations to be fully vapor sealed.
   4. Stop and point insulation around access doors and damper operators to allow operation without disturbing insulation or jacket material.
   5. External supply duct insulation is not required where ductwork contains continuous 1" acoustical liner. Provide 4" overlap of external insulation over ends of acoustically lined sections.
   6. Where insulated ductwork is supported by trapeze hangers, the insulation shall be installed continuous through the hangers. Drop the supporting channels required to facilitate the installation of the insulation. Where rigid board or flexible insulation is specified, install high density inserts to prevent the weight of the ductwork from crushing the insulation.
   7. Where insulated low temperature (below 45°F) ductwork is supported by steel metal straps or wire ropes that are secured directly to the duct, the straps or ropes shall be completely covered with insulation and sealed to provide a complete vapor barrier.
   8. Where insulated duct risers are supported by steel channels secured directly to the duct, extend the insulation and vapor barrier jacketing to encapsulate the support channels.
   9. Where ductwork exposed to the weather is insulated with any product other than fluid-applied ductwork insulation, the top surface of the insulation shall be sloped a minimum of ¼" per foot to eliminate ponding and create positive drainage off of insulation. Refer to fluid-applied ductwork insulation section below for slope requirements.

B. Breeching: Fasten insulation over weld pins and secure with washers. Space fasteners not less than 3” from edge or corner and 12" on center longitudinally and 9" on center in the transverse direction. Clip pins back to washer and cover penetrations with tape of same material as jacket. Firmly butt seams and joints and cover with 4” tape of same material as jacket. Seal tape with plastic applicator and secure with staples.

3.08 DUCTWORK PROTECTIVE COVERINGS

A. In addition to the jackets specified in the duct insulation schedule below the following protective coverings are required:
   1. Provide a protective covering of 2 coats of indoor/outdoor vapor barrier mastic with metal jacket or canvas fabric covering (FMJ) for the following ductwork: Ductwork within 32T of floor, catwalks and mezzanines in mechanical rooms.

3.09 DUCT INSULATION SCHEDULE

A. Provide duct insulation on new and existing remodeled ductwork in the following schedule:

Service	**Insulation Type**	**Jacket**	**Insulation Thickness**
Outside air ducts	Rigid Fiberglass	FSJ	2"
Mixed air ducts	Rigid Fiberglass	FSJ	2"
Exposed supply ducts*	Rigid Fiberglass	FSJ	2"
Concealed supply ducts	Flexible Fiberglass	FSJ	2"
Supply ductwork downstream of VAV boxes	Flexible Fiberglass		2”
Supply ductwork downstream of VAV boxes as indicated on drawings	Duct Liner Insulation		1-1/2”
Ductwork in unconditioned space	Rigid Fiberglass	FSJ	2"
All Ducts located in unconditioned Attics***	Flexible Fiberglass	FSJ	3”
All ducts exposed to weather	Ext. Polystyrene or Fluid-Applied**	SAJ	3"

* Exposed supply <u>branch</u> ducts located in the space they are serving do not require insulation. Exposed supply <u>main</u> ducts running through spaces they serve shall be insulated as exposed supply ducts scheduled above.

** No jacket is required for Fluid-Applied ductwork insulation. The two part Fluid-Applied system serves as insulation and protective jacket.

*** Outside air ductwork between the isolation damper and the outside air intake does not require insulation where it is located in an unheated attic.

B. Fluid-Applied Ductwork Insulation (FDI):
   1. Proceed with work only when weather conditions comply with Manufacturer recommendations and other current published data and MSDS information. Do not exceed temperature limitations recommended by coating manufacturer.
   2. The top of ducts insulated with fluid-applied ductwork insulation shall be sloped using tapered insulation prior to applying fluid-applied insulation. Tapered Insulation shall be ASTM C1289, Type II, Class 1, Grade 2; rigid board polyisocyanurate insulation with felt or fibrous mat facing on both sides, factory tapered to 1/2” per foot slope. Tapered insulation board shall have a start thickness at the perimeter of 1/2”. Tapered insulation board shall be mechanically fastened to ductwork. Tapered insulation applied to rectangular ductwork less than or equal to 24” in width may be sloped from one side. Tapered insulation applied to rectangular ductwork greater than 24” in width shall be sloped in two directions with the high point at the centerline of the duct.
   3. Air intake vents, blowers, air conditioning units and evaporative coolers shall be disconnected or otherwise modified to prevent fumes from entering into the building or from contaminating the substrate surface with condensate water.
   4. Coordinate scheduling with the Owner in order to relocate or protect vehicles, building occupants and building contents from damage during construction operations.
   5. Existing materials designated to remain, which are damaged or defaced as a result of the work shall be replaced at Contractor's expense to like new condition.

6. [Reinstall] [Install] all rooftop mounted equipment in a watertight manner and repair any damage to sheet metal or other components related to connection and protection of the system.
7. Prevent materials from entering and clogging roof drains and conductors. Remove roof drain plugs when no work is taking place or when rain is forecast.
8. Protection of surfaces:
    a. Take every precaution to prevent water leakage or debris falling into the building interior, or other such occurrences. Contractor is responsible for any damage to the building interior, or contents, during application.
    b. Provide special protection or avoid heavy traffic on completed work or roof surfaces. Temporary walkways and work platforms shall be provided as necessary.
    c. Wall surfaces shall be protected with tarpaulins or other suitable cover to prevent damage, staining or discoloration that might result from operations. Windows, doorways, docks, walkways, etc. may require special protection measures.
9. Protect building and adjacent area and property within the area from over spray.
10. **Caution**: Installation of primers, polyurethane foam or coatings shall not interfere with the proper function of: Manual Volume Dampers, Turning Vanes, Fire Dampers, Smoke Dampers and Combination Fire/Smoke Dampers, Control Dampers, Smoke Detectors, Access Doors, Duct Pressure Relief Doors, Flashings, Duct Flexible Connections, Sound Attenuators, Hoods for Intake and Exhaust, Louvers, Air Blenders and Air Flow Stations.
11. Installation of Spray Polyurethane Foam (SPF) Insulation:
    a. When required, install approved polyurethane foam to an average thickness as specified in the duct insulation schedule (1" minimum required) and terminated neatly at designated places.
12. Mask areas where coating is to be terminated to prevent surface contamination with foam over spray.
13. Foam spray application shall be limited to that which can be completed to full foam thickness in one day. All exposed foam tie-in end laps and side laps must be primed at the end of each workday.
14. The completed foam surface shall be smooth to orange peel texture; popcorn texture is not acceptable.
15. The completed foam surface shall be free of pinholes and/or "glass windows" caused by improper equipment calibration or climatic conditions. The SPF shall not have any soft or spongy areas or areas with hard or brittle strings of improperly proportioned material
16. Eliminate areas of ponding using approved polyurethane foam to create positive drainage.
17. Remove protective masking at terminations.
18. Apply protective coating to foam surface on the same day as polyurethane foam is installed.
19. The foam shall not be left exposed or uncoated for more than 4 hours. If coating application is delayed beyond that time, consult manufacturer for primer recommendations.
20. Installation of Coating System:
    a. General:
        1) Do not apply coating when moisture is present on the substrate.
        2) Wind barriers shall be used if wind conditions could affect the quality of the material being applied.
        3) Coating must cover all surfaces completely. An extra pass of coating material may be required at all edges and penetrations.
        4) Base coat(s) and primer(s) shall be allowed to cure before proceeding with subsequent applications.
        5) All coating and primers shall be coated within recommended time period. If application is delayed beyond that time, consult Manufacturer for primer recommendations.
    b. Application Thickness:
        1) 15 Year NDL System
        2) Average Application Thickness: Topcoat Average thickness shall be 36 Average TDM, (3.0 gallons per 100 sq. ft. minimum application recommended.)
        3) Application rates must be checked periodically to assure proper coating thickness. This may be done by checking dry film thickness.

4) Contractor to estimate coating requirements based on actual experience and needs to figure losses due to applicator experience, surface texture, wind, waste, and other factors increasing estimated gallons required.
5) The total dry mil thickness of all coatings, as well as the total dry mil thickness of the topcoat(s) shall meet the minimums required by Manufacturer.

c. Application of approved polyurea coating:
1) Spray apply approved polyurea coating to achieve the required TDM (Total Dry Mils). The polyurea shall completely cover the SPF including all termination, penetrations, expansion joint covers, parapets and flashings. Spray pattern shall overlap the previous pass to insure complete coverage.
2) To assure complete coverage with approved polyurea coating, applicator needs to figure losses due to over-spray, surface texture and wind and increase the gallons as needed to meet specifications.
3) Pay special attention to overspray, which can texture or discolor adjoining finished sections. Wind direction should conduct overspray away from finished surfaces.

3.10 EQUIPMENT INSULATION

A. General: Do not insulate over equipment access manholes, fittings, nameplates or ASME stamps. Bevel and seal insulation at these locations.
B. All equipment with fluid temperatures 50° F or less shall be insulated. If the equipment is not listed in the Equipment Insulation Schedule below, provide removable 1 inche thickness Elastomeric/Polyolefin on these mechanical equipment and devices. For mechanical equipment furnish and install insulation and removable elastomeric insulation covers, plugs or caps for all mechanical equipment and devices. Covers shall be tight fitting to ensure a complete vapor barrier.
C. Protective Jackets: Provide a protective metal jacket (PMJ) for the following: Generator exhaust pipe (that is not concealed in a shaft) and muffler.
D. Semi-Rigid Fiberglass: Apply insulation to equipment shells using weld pins, bonding adhesive, banded and wired in place. Fill all joints, seams and depressions with insulating cement to a smooth, even surface. Cover with reinforcing fabric and 2 coats of mastic (FMJ). Use vapor barrier mastic on systems requiring a vapor barrier.
E. Elastomeric/Polyolefin: Apply full cover coat of adhesive to surface to be insulated, insulation and edge butt joints. Place insulation with edge joints firmly butted pressing to surface for full adhesion. Seal seams and joints vapor tight.
F. Removable Covers:
1. Provide insulated easily removable galvanized steel metal boxes for routine service access on the following equipment:
2. Provide insulated easily removable elastomeric insulation sections for the following equipment:

3.11 EQUIPMENT INSULATION SCHEDULE

A. Provide equipment insulation as follows:

Equipment	Insulation	Jacket	Thickness Type
Reheat coil casing in exposed supply ducts	Rigid Fiberglass	FSJ	2"
Reheat coil casing in concealed supply ducts	Flexible Fiberglass	FSJ	2"
Air Handling Unit Casings or attached component sections not factory insulated**	Rigid Fiberglass	ASJ	2”

* Condenser shell only needs to be insulated when condenser is city, lake, or river water cooled or when "free cooling" is used.
** The thickness and type of insulation provided for non-factory fabricated transitions or component sections shall be consistent with the sections constructed at the factory.
*** Protective metal jacket (PMJ) is only required in exposed locations.

END OF SECTION

SECTION 23 09 14
PNEUMATIC AND ELECTRIC INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Base Bid: Unless noted otherwise, the Temperature Control Contractor shall provide all labor and materials for a complete system in this specification section.

1.02 SECTION INCLUDES

A. This section includes pneumatic control system specifications for all HVAC work as well as related pneumatic control for systems found in other specification sections. Included are the following topics:
   1. Control Dampers
   2. Control Valves
   3. Control System Instrumentation
   4. Electric/Electronic Thermostats
   5. Duct Smoke Detector and Fire Alarm Interface Modules
   6. Time Clocks
   7. Temperature Control Panels
   8. Temperature Sensors
   9. Humidity Sensors
   10. Pressure Transducers (Air)
   11. Differential Pressure Switches
   12. Air Pressure Safety Switches
   13. Current Status Switches
   14. Electric to Pneumatic Transducers
   15. Power Supplies

1.03 RELATED WORK

A. Applicable provisions of Division 1 govern work under this section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC - Coordination
D. Section 23 09 23 – Direct Digital Control System for HVAC
E. Section 23 09 93 – Sequence of Operations for HVAC Controls
F. Section 23 15 00 – Piping Specialties
G. Section 23 31 00 – HVAC Ducts
H. Section 23 33 00 – Ductwork Accessories - for control damper installation
I. Division 23 - HVAC - Equipment provided to be controlled or monitored

1.04 SUBMITTALS

A. Refer Section 23 05 00 – Common Work Results for HVAC, Submittals. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Control Dampers
   2. Control Valves
   3. Control System Instrumentation
   4. Electric/Electronic Thermostats
   5. Duct Smoke Detector and Fire Alarm Interface Modules
   6. Temperature Control Panels
   7. Temperature Sensors
   8. Humidity Sensors
   9. Pressure Transducers (Air)
   10. Differential Pressure Switches
   11. Air Pressure Safety Switches
   12. Current Status Switches

13. Electric to Pneumatic Transducers
14. Power Supplies

B. Include the following information:
   1. Manufacturer's data sheets indicating model number, pressure/temperature ratings, capacity, methods and materials of construction, installation instructions, and recommended maintenance. General catalog sheets showing a series of the same device is not acceptable unless the specific model is clearly marked.
   2. Schematic flow diagrams of systems showing fans, pumps, coils, dampers, valves, and other control devices. Label each device with setting or adjustable range of control. Indicate all wiring, clearly, differentiating between factory and field installed wiring. Wiring should be shown in schematics that detail contact states, relay references, etc. Diagrammatic representations of devices alone are not acceptable.
   3. Details of construction, layout, and location of each temperature control panel within the building, including instruments location in panel and labeling. Also include on drawings location of mechanical equipment controlled (room number), horsepower and flow of motorized equipment (when this data is available on plans), locations of all remote sensors and control devices (either by room number or column lines).
   4. Schedule of control dampers indicating size, leakage rating, arrangement, pressure drop at design airflow, and number and size of operators required.
   5. Schedule of control valves indicating system in which the device is to be used, rated capacity, flow coefficient, flow required by device served, actual pressure drop at design flow, size of operator required, close-off pressure, and locations where valves are to be installed.
   6. A complete description of each control sequence for equipment that is not controlled by direct digital controls. Direct digital controlled equipment control sequences will be provided by the DDC control contractor.
   7. Calculations completed to determine size of control air compressor(s) and dryer (s).

C. Prior to request for final payment, submit record documents which accurately record actual location of control components including panels, thermostats, wiring, and sensors. Incorporate changes required during installation and start-up.

D. All submittals are to comply with submission and content requirements specified in specification Section 01 91 13.

1.05 REFERENCE STANDARDS

A.	ANSI B16.22	Wrought Copper and Wrought Copper Alloy Solder Joint Pressure Fittings
B.	ANSI/ASTM B32	Specification for Solder Metal
C.	ASTM B75	Seamless Copper Tube
D.	ASTM D1693	Environmental Stress-Cracking of Ethylene Plastics
E.	ASTM D 635	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
F.	UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
G.	AMCA 500-D	Laboratory Method of Testing Dampers for Rating
H.	ASHRAE Guideline 16-2010	Selecting Outdoor, Return and Relief Dampers for Air-Side Economizer Systems

1.06 QUALITY ASSURANCE

A. Manufacturers: Installing contractor must be a manufacturer's branch office or an authorized representative of a Direct Digital Control (DDC) equipment manufacturer that provides engineering and commissioning of the DDC equipment. Submit written confirmation of such authorization from the manufacturer. Indicate in letter of authorization that installing contractor has successfully completed all necessary training required for engineering, installation, and commissioning of equipment and systems and that such authorization has been in effect for a period of not less than three years. DDC equipment may or may not be required to be installed by this contractor as part of the project, but the intent of this quality assurance specification is to ensure that the installing contractor

has the capabilities to engineer, install, and commission the field devices supplied under this section for temperature control.

1.07 DESIGN CRITERIA

A. Size all control apparatus to properly supply and/or operate and control the apparatus served. For example, damper and valve actuators shall have sufficient power to operate their respective valve or damper from 0 to 100% under load smoothly, without jerking or hysteresis.
B. Provide control devices subject to corrosive environments with corrosion protection or construct them so they are suitable for use in such an environment.
C. Provide devices exposed to outside ambient conditions with weather protection or construct them so they are suitable for outdoor installation.
D. Use only UL labeled products that comply with NEMA Standards. Electrical components and installation to meet all requirements of the electrical sections (Division 26) of project specifications.

1.08 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 – Common Work Results for HVAC.
B. In addition to the general content specified Section 23 05 00 – Common Work Results for HVAC, supply the following additional documentation:
    1. Lubrication instructions, including list/frequency of lubrication
    2. List indicating types and grades of oil and/or grease, packing materials, normal and abnormal tolerances for devices, and method of equipment adjustment
    3. Table noting full load power factor, service factor, NEMA design designation, insulation class and frame type for each motor provided
    4. A complete set of record drawings

1.09 DELIVERY, STORAGE AND HANDLING

A. Provide factory shipping cartons for each piece of equipment and control device. This contractor is responsible for storage of equipment and materials inside and protected from the weather.

1.10 SYSTEM DESCRIPTION

A. System is to use direct digital control with electric actuation for roof top air handling unit; direct digital control with electric actuation for room temperature, room humidity, and terminal airflow control; and electric control for other terminal units.

1.11 DEMOLITION

A. Where existing control devices, piping, or wiring are discontinued from use, remove and turn over to owner. If owner does not want them remove from premises. Remove any previously abandoned control devices in a similar manner.

PART 2 – PRODUCTS

2.01 CONTROL DAMPERS

A. Provide control dampers shown on the plans and as required to perform the specified functions. Dampers shall be rated for velocities that will be encountered at maximum system design and rated for pressure equal to or greater than the ductwork pressure class of the ductwork where the damper is installed, as specified in Section 23 31 00 – HVAC Ducts and Casings.
B. Use only factory fabricated dampers with mechanically captured replaceable resilient blade seals, stainless steel jamb seals and with entire assembly suitable for the maximum temperature and air velocities encountered in the system.
C. All dampers in stainless steel, PCD coated steel, PVC, PTFE, or fiberglass ductwork shall be constructed of stainless steel.
D. All dampers in aluminum ductwork shall be constructed of stainless steel or aluminum.
E. Dampers in galvanized ductwork shall be constructed of galvanized steel and/or aluminum.

F. All dampers, unless otherwise specified, to be rated at a minimum of 180º F working temperature. Leakage testing shall be certified to be based on latest edition of AMCA Standard 500-D and all dampers, unless otherwise specified, shall have leakage ratings as follows:

Damper Class	Differential Pressure	Leakage
Class IA	1" w.g.	$\leq$3 CFM/ft^2
Class I	4" w.g.	$\leq$8 CFM/ft^2
Class I	8" w.g.	$\leq$11 CFM/ft^2
Class I	12" w.g.	$\leq$14 CFM/ft^2

G. Leakage rate dampers for differential pressures that they will encounter at maximum system design pressures.

H. Steel framed dampers: Nailor models 2010 & 2020; Greenheck models VCD-33 & VCD-42; Johnson Controls model V-1330; Ruskin Models CD60 & CD40.

I. Aluminum frame and blade dampers: Nailor models 2010EAF & 202EAF; Greenheck model VCD-43; Ruskin model CD50; Arrow model AFD-20.

J. Dampers used for directed mixing of airstreams, i.e. outside air and return air, to be parallel blade type and sized for an air velocity of 1800 to 2000 fpm with the damper blades shall be arranged so that the air streams are directed at one another to facilitate mixing. Dampers used for throttling or modulating applications other than air stream mixing to be opposed blade type. Two position dampers may be parallel or opposed blade type.

K. Dampers used for isolation on the discharge of centrifugal fans shall have damper blades perpendicular to the fan shaft to minimize system effect. Dampers mounted with blades vertically shall be designed for vertical blade orientation.

L. Dampers for applications to have frames of not less than 16-gauge galvanized steel or 12-gauge extruded aluminum. Blades to be two-ply steel airfoil of not less than 2 x 20-gauge galvanized steel (14-gauge equivalent) or extruded aluminum airfoil, with stainless steel, acetal, Celcon, bronze, or nylon bearings. Maximum allowable blade width is 8 inches. Use plated steel linkage hardware.

M. Maximum damper width is 48 inches; where required width exceeds 48 inches, use multiple damper sections. Inside frame free area shall be a minimum of 90% of total inside duct area.

N. Multiple width damper sections shall utilize jack shaft linkages unless noted below. Sections over 144 inches wide shall be actuated from two locations on the jack shaft. Double width damper sections for two-position operation may be actuated without jack shafts if each damper section is actuated separately. Dampers that have multiple width and multiple vertical sections shall have a jackshaft for each vertically stacked set of dampers and be provided with crossover linkages between jack shafts to transfer uneven loading.

O. Jack shafts shall be extended outside of the ductwork for external actuator mounting. Provide bearings on the point of exit for support of damper shafts to prevent wear on the shaft and the ductwork. If locating actuators out of the air stream is impossible, obtain mounting location approval from the A/E unless the contract documents indicate in air stream mounting is acceptable. In no cases shall damper actuators for fume exhaust systems be located in the air stream or require entering the air stream to service an actuator.

P. Provide weatherproof NEMA 4 enclosures (Belimo N4 option, Belimo ZS-100 or ZS-150 are not acceptable) that have removable covers that have clasps or machine screws (no sheet metal screws) and that do not require removing fasteners from the ductwork to prevent actuator failure or freeze-up when mounting in locations exposed to harsh environments or outdoor locations.

Q. Size operators for smooth and positive operation of devices served, and with sufficient torque capacity to provide tight shutoff against system temperatures and pressure encountered.
   1. For pneumatic actuation, use rolling diaphragm, piston type operators with adjustable stops.
   2. For electric modulating actuation, use fully proportional actuators with zero and span adjustments.
   3. For terminal unit actuators, stepping motors may be used and zero and span is not required.
   4. For two-position electric actuation use 24 VAC for DDC controlled actuators, 120 VAC actuators may be used for hardwire interlocking.

R. Refer to control diagram/point chart on drawings for specific type of input signal required. Actuator stroke times shall match the requirements of the DDC controllers provided under Section 23 09 23 – Direct Digital Control System for HVAC and/or the specific system requirements for proper operation. All electric actuators will be provided with overload protection to prevent motor from damage when stall condition is encountered. Equip operators with spring return or stored energy fail-safe return for applications involving fire, freeze protection, moisture protection or specified normally open/closed

operation. Provide damper end switches with form "C" contacts where control sequences require damper position indication. End switches shall not contain mercury.

S. All power required for electric actuation shall be provided by this contractor if it is not able to be directly provided from the DDC controller.
T. Provide operators with linkages and brackets for mounting on device served.
U. Provide pilot positioners for pneumatic operators serving all modulating outside air, return air, relief air, and face and bypass dampers, where more than one operator is controlled in sequence, or where required to provide sufficient power to the operator.
V. All outdoor air, return air, and relief air dampers to be sized in accordance with the ASHRAE Guideline 16-2010.

2.02 CONTROL VALVES

A. Provide all control valves as shown on the plans/details and as required to perform functions specified. Spring ranges must be selected to prevent overlap of operation and simultaneous heating and cooling.
B. Valve Selection Criteria:
   1. Submit engineering calculations for sizing modulating control valves unless valves are scheduled. Control valves serving terminal devices may be sized based on flow ranges for each pump system.
   2. Calculations for sizing modulating valves shall be based on actual characteristics of equipment and system in which valves are installed. Valve calculations shall include information such as pump head or available pressure
   3. Temperature Control Contractor is responsible for obtaining adequate system information necessary for sizing.
   4. Select control valves to meet their intended service without cavitation. Provide cavitation calculations for modulating globe control valves over 250°F and all modulating butterfly valves over 60°F.
   5. Select control valves and actuators for 100% shut-off against system's maximum differential pressure.
   6. Provide valve trim to limit audible sound levels to 85 dBA or less when measured at 5 feet.
C. Size operators to allow smooth and positive operation of devices served and to provide sufficient torque capacity for tight shutoff against system temperatures and pressure encountered.

   1. For electric modulating actuation, use fully proportional actuators with 0-10VDC inputs and zero and span adjustments unless specified otherwise in the chart below.
D. If TriState with feedback is specified, valve position shall be fed back to the controller and controller shall position valve based on this feedback.
E. For two-position electric actuation use 24 VAC for DDC controlled actuators, 120 VAC actuators may be used for hardwire interlocking.
F. Electric actuators, for applications other than terminal units, shall be provided with a manual override capability. All electric actuators shall be provided with a visible position indicator.
G. All power required for electric actuation shall be provided by this contractor if it is not able to be directly provided from the DDC controller.
H. Provide operators that are full proportioning or two-position, as required for specified sequence of operation. Provide spring-return for applications involving fire, freeze protection, moisture protection or specified normally open/closed operation. Valves shall move to their fail positions on loss of electrical power or air pressure to the actuator.
I. Two-position and shut-off valves shall be sized for a maximum pressure drop of 2 PSI at design flow and shall be a minimum of line size.
J. Provide operators with linkages and brackets for mounting on device served.
K. All valves unless specifically noted on the plans or indicated below shall be globe style valves.

VALVE SERVING	**TYPE** Globe Butterfly (BF) Ball Press Independent Ball (PI Ball)	**SIGNAL** 0-10 VDC 2-Position Elect Pneumatic (Pneu)	**SPRING RETURN** REQUIRED Yes No	**FAIL POSITION** Open (thru Coil) Closed (bypass Coil) Last Position

Reheat Coil	Globe or Ball	0-10 VDC or TriState w/feedback	No	Last Position
CUH and UH	Globe or Ball	2-Pos Elect	Yes	Open

L. See plan details, notes, and schedules for where two-way and three-way valves should be used.
   1. Equivalent Cv butterfly valves may be used where 3" and larger globe valves would be required.

M. WATER SYSTEMS:
   1. Use equal percentage valves for two-way control valves; size for a pressure drop not less than 4 psi or more than 6 psi. Select control valves based upon pressure drop calculations and Cv values at 100% stroke. Note: For low flows, the required minimum Cv size will result in lower pressure drop than 4 psi.
   2. Select control valves based upon pressure drop calculations and Cv values at 100% stroke
   3. Use three-way valves sized for a maximum pressure drop of 5 psi and that have linear characteristics so that the valve pressure drop remains constant regardless of the valve position.
   4. Globe valves 2" and smaller: Cast bronze or forged brass body, brass plug and brass or stainless-steel seat, stainless steel stem, screwed ends, suitable for use on water systems at 150 psig and 240° F. Seat leakage with actuator supplied will meet ANSI class IV leakage (0.01%). Only the following globe valve body styles will be acceptable for terminal unit control: Siemens Powermite 599 VF Series (599 VE Series Zone Valves are not acceptable), Invensys VB7200 Series, Johnson Controls VG7000 Series, and Honeywell V5011/V5013 Series. Minimum size for globe valves shall be 1.5 Cv.
   5. Butterfly valves: Iron body, stainless steel shaft, bronze bearings, and resilient seat. Disc to be aluminum-bronze, nickel-plated ductile iron, cast iron with welded nickel edge, or stainless steel. Valve assembly to be bubble tight, suitable for use on water systems at 150 psig and 240° F. Only the following butterfly valve manufacturers will be acceptable: DeZurik, Xomox, Jamesbury, Posi-Seal, Bray/McCannalok or Fisher.
      a. When butterfly valves are used in modulating applications, entering and leaving pipe sizes and required transition distances shall be detailed on the control valve submittals.
      b. The Temperature Control Contractor shall be responsible for coordinating the proper pipe sizes and transitions with the Mechanical Contractor to provide the correct Cv at 70° open position.
      c. For pneumatically actuated valves, provide pilot positioners on all operators for butterfly valves used in modulating applications. Provide limit switches as required.
      d. Valves and actuators shall be manufactured by valve manufacturer. Valve assembly including actuator, positioner and limit switches if used shall be assembled by valve manufacturer.
   6. Characterized Ball Valves: The following manufacturers are acceptable: Honeywell, Belimo, Johnson Controls, KMC Controls, Yamatake. For use on terminal units only where specified above. Forged brass or bronze body, stainless steel shaft and ball, reinforced Teflon or PTFE ball seals, double O-ring stem seals, characterized disk, maximum of ANSI Class IV (0.01%) leakage, suitable for use on water systems at 150 psig and 212° F. Minimum size for ball valves shall be 1.0 Cv.
   7. Pressure Independent Characterized Ball Valves: The following manufacturers and models are acceptable: Belimo model PICCV and Griswold Controls PIC-V. For use on terminal units only where specified above. Forged brass or bronze body, reinforced Teflon or PTFE ball seals, double O-ring stem seals, characterized disk, maximum of ANSI Class IV (0.01%) leakage, suitable for use on water systems at 150 psig and 212° F. Flow shall be varied by actuator position and at any given position, flow through the valve shall not vary more than +/- 5% due to system pressure fluctuations across the valve in the selected operating range. Valves shall be pressure independent between a system differential pressure of 8 and 50 PSID. Minimum size for ball valves shall be 1.0 Cv.

N. Instrumentation Valves: Unless otherwise noted, instrumentation shut-off valves for isolation of gauges, switches, transmitters, etc., shall be as follows:
   1. Water systems: globe-type valves
   2. Ductwork, air handling unit or air terminal device penetrations: ball or plug-type valves
   3. Liquid line sampling valves: multiple turn, metering-type valves.

O. Solenoid Valves: Valves shall be brass or bronze body. Select valves to match required temperatures and pressures and shall have materials that are compatible with intended working fluids. Line voltage actuators shall be Class "H" (high temperature), listed by UL or CSA. Manufacturers: Asco, Siebe Environmental Controls, Honeywell, Johnson Controls, Siemens (Landis and Staefa), Moore Industries, Robertshaw, or Schrader Bellows.

P. Damper and Valve Actuators:

1. Analog Electronic: Actuators shall be hydraulic or electric motor/gear drives that respond proportionally to analog voltage or current input. Stroke time for major equipment shall be 90 seconds or less for 90° rotation. Stroke time for terminal equipment shall be compatible with associated local controller, but no more than 6 minutes. Provide spring return feature for fail open or closed positions, as required by control sequence, for critical applications such as outside, return, or exhaust dampers, heating and cooling coils on major air handling units, humidifiers, heat exchangers, flow control for major equipment items such as chillers, cooling towers, boilers, etc. Provide position feedback potentiometers connected to controller for closed loop control on major equipment analog control loops. Actuators for terminal heating/cooling equipment do not require spring return feature. Acceptable manufacturers: Belimo.
2. Discrete Two-Position Electric: Actuators shall be hydraulic or electric motor/gear drives for two-position control. Stroke time shall be 90 seconds or less for 90° rotation. Provide spring return feature for fail open or closed positions as required by control sequence. Acceptable manufacturers: Belimo.

2.03 CONTROL SYSTEM INSTRUMENTATION

A. Manufacturers: Averaging Type - Johnson Controls; Bulb Type - Johnson Controls, Ashcroft, Marshall, Weksler

B. Duct Thermometers: 3 inch or larger dial type with swivel mount. Maximum scale graduations of 2°F. Thermometers in ducts above 6 square feet to have averaging type, liquid or gas filled capillary sensing elements a minimum of 6 feet and supported across the width of the duct. Thermometer temperature range shall not be more than twice the expected temperature range at installed location.

C. Pipe Thermometers: 9-inch stem type with an adjustable swivel mount. Scale graduations of 2°F and mid-range accuracy of ±1°F. Install thermometers in separable brass wells filled with conductive fluid. Thermometer temperature range shall not be more than twice the expected temperature range at installed location.

D. Remote Bulb Thermometers: 3 inch or larger dial type with recalibration screw on face. Accuracy within 1% of scale range. Thermometers with sensing elements in air ducts with an area of above 6 square feet to have averaging liquid or gas filled capillary sensing elements. Provide separable wells for all pipeline applications. Thermometer temperature range shall not be more than twice the expected temperature range at installed location.

2.04 ELECTRIC/ELECTRONIC THERMOSTATS

A. Electric Thermostats: For single setpoint applications, provide line or low voltage electric type suitable for heating or heating and cooling as required. Provide the required number of heating and/or cooling stages required for the application. For line voltage ventilation applications utilizing fans and where otherwise specified in the sequence of operations, provide an integral manual On/Off/Auto selector switch. Minimum contact rating shall be equal to electrical load of device being controlled.

B. Low Voltage Electronic Thermostats:

1. Manufacturers: Honeywell, Johnson Controls, Viconics.
2. Where unoccupied setpoints are specified, provide electronic programmable type with seven-day setup/setback scheduling with a minimum of two occupied and unoccupied schedules per day through keypad entry on front of unit. For heating and cooling applications, provide automatic heating/cooling switchover. For applications that control fans, provide fan override switch. For ventilation or packaged economizer applications provide a dry contact for ventilation damper or economizer initiation. For thermostat control of economizer, provide a 0-10VDC modulated output for economizer damper control.
3. For applications that require integration to the building automation system, provide a BACnet communication interface. If a communication interface is specified, occupancy scheduling in the thermostat is not required.

C. Low Limit Thermostats (Freeze stats): Electric two-position type with temperature sensing element and manual reset. Unit to be capable of opening control circuit if any one-foot length of sensing element is subject to a temperature below the setpoint. Length of sensing element to be not less than one lineal foot per square foot of coil surface areas. Unless otherwise indicated, set low limit controls at 36°F.
D. Aqua stats: Line voltage type with single pole, double throw switch of adequate rating for the applied load.
E. Remote Bulb Thermostats: Line voltage type with single pole, double throw switch of adequate rating for the applied load. Thermostat to have adjustable setpoint suitable for controlled load.
F. Immersion Type Thermostat Sensors: Rod and tube type with linear output. Provide separable wells with heat conductive fluid for installation in pipeline. Units shall be factory calibrated.
G. Firestats: UL labeled, manual reset, line voltage type with 135°F setpoint.

2.05 DUCT SMOKE DETECTOR AND FIRE ALARM INTERFACE MODULES

A. Detectors with auxiliary contacts or fire alarm control modules will be provided by Division 28. Provide wiring, conduit, and necessary interface with fire alarm system to perform specified sequence of operation.

2.06 TEMPERATURE CONTROL PANELS

A. Constructed of steel or extruded aluminum, with hinged door, keyed lock, and baked enamel finish. Install controls, relays, transducers and automatic switches inside panels. Label devices with permanent printed labels and provide as built wiring/piping diagram within enclosure. Provide raceways for wiring and poly tubing within panel for neat appearance and to separate high and low voltage wiring. Provide termination blocks and resettable circuit breaker for 120VAC power wiring. Provide label within the panel indicating circuit number of 120VAC serving panel. Label outside of panel with panel number corresponding to plan tags and as built control drawings as well as building system(s) served.
B. Provide a service shutdown toggle switch for each air handling unit system located inside the temperature control panel that will initiate a logical shutdown of the air handling unit system. Label the switch so it is clear which position is shut down and which is auto.
C. Manual switches including damper "minimum-off" positioning switches, "summer-winter switches", "manual-automatic switches", dial thermometers, pressure gauges, and receiver indicating gauges shall be flush mounted in front door of panel. Clearly identify each item with engraved nameplates.

2.07 TEMPERATURE SENSORS

A. Thermistor temperature sensor manufacturers: PreCon, BAPI, and ACI
B. Use thermistor or RTD type temperature sensing elements constructed so accuracy and life expectancy is not affected by moisture, physical vibration, or other conditions that exist in each application.
C. RTD's shall be of nickel or platinum construction and have a base resistance of 1000Ω at 70°F and 77°F respectively. 100Ω platinum RTD's are acceptable if used with temperature transmitters.
D. The temperature sensing device used must be compatible with the DDC controllers used on the project.

RTD	
Accuracy (Room Sensor Only)	minimum ± 1.0°F
Accuracy (Averaging)	minimum ± 1.2°F
Accuracy (Other than Room Sensor or Averaging)	minimum ± 0.65°F
Range	minimum -40 - 220°F
Thermistor	
Accuracy (All)	minimum ± 0.36°F
Range	minimum -30 - 230°F
Heat Dissipation Constant	minimum 2.7 mW/°C
Temperature Transmitter	
Accuracy	minimum ± 0.1°F or ±0.2% of span
Output	4-20 mA

E. Provide limited range or extended range sensors if required to sense the range expected for a respective point. Use RTD type sensors for extended ranges beyond -30 to 230°F. If RTD's are incompatible with DDC controller direct temperature input, use temperature transmitters in conjunction with RTD's.
F. Use wire size appropriate to limit temperature offset due to wire resistance to 1.0°F. If offset is greater than 1.0°F due to wire resistance, use temperature transmitter. If feature is available in DDC controller, compensate for wire resistance in software input definition.
G. Provide sensors in occupied spaces with brushed aluminum or brushed nickel covers unless otherwise noted or features specified will not allow for this. Sensors in unoccupied spaces shall have metal enclosure. Terminal unit sensors with setpoint adjustments and digital displays may use plastic covers. Provide information to the AE on sensor colors offered by the manufacturer and obtain approval on what color should be provided on the project.
H. Terminal unit sensors shall be provided with digital displays that indicate room temperature and setpoint and have a manual occupancy override and indication of occupancy status. Provide setpoint adjustment as specified in the control diagram and sequence of operation.
I. Use averaging elements on duct sensors when the ductwork is ten square feet or larger. All mixed air and heating coil discharge sensors shall have averaging elements regardless of duct size.
J. In piping systems use temperature sensors with separable wells designed to be used with temperature element.

2.08 HUMIDITY SENSORS

A. Use capacitive thin-film polymer sensor types with a range of 0-100% RH. Accuracy to be no less than ±1% in the range of 20% RH to 80% RH with a response time of 120 seconds or less. Provide covers for room humidity sensors as specified for temperature sensors.
B. For outside air applications, use sensor designed for outside air use along with weather enclosure. Provide sensor equal to Vaisala Model HMD60UO w/ DTR503B enclosure and weather resistant mounting hardware.

2.09 PRESSURE TRANSDUCERS (AIR)

A. Provide pressure transducers specified below for the following applications:
   1. Duct static pressure applications where setpoints are specified to control at greater than 0.1" w.c.
   2. Pitot type fan inlet air flow stations.
   3. Terminal unit air flow measurement regardless of the minimum velocity pressure unless otherwise noted in the contract documents.
B. Manufacturers: Mamac Systems, Setra, and Veris Industries.
C. Provide a transmitter that operates on the capacitance principle and is capable of sensing low positive, negative or differential pressures. Transmitter shall have a minimum of three pressure ranges adjustable by an onboard switch or jumper. Size the transmitter where the middle or high range is suitable for the application. Use a bi-directional transmitter for applications that may have both positive and negative pressure excursions. Transmitter shall be provided with an integral four-digit display of the pressure sensed.

Accuracy (including non-linearity and hysteresis)	± 1% FS
Compensated Temperature Range	32°-140° F
Temperature Effect	0-1"wc Range .09% FS/°F; >1"wc Range .02% FS/°F
Output	4-20 MA
Load Impedance (smallest maximum acceptable)	800 Ω max.
Operating Temperature	32°-140° F

D. Pressure transducers used for supply VAV box flow applications do not need to have adjustable pressure ranges or integral display.
E. Provide pressure transducers specified below for the following applications:
   1. Duct static pressure applications where setpoints are specified to control at 0.1" w.c. or lower.
   2. All duct mounted pitot type air flow stations.
   3. Space/building static control or monitoring.
F. Manufacturers: Paragon Controls MicroTrans, Air Monitor Veltron DPT2500 Plus.

G. The airflow transducer shall provide noise filtration and automatic auto-zeroing. The automatic zeroing circuit shall be capable of maintaining the transducer output to within ±0.25% of operating span. The transducer output shall be locked and maintained at the last given output value during the automatic zeroing period so as not to interrupt the automatic control process. Use a bi-directional transmitter for applications that may have both positive and negative pressure excursions. Transmitter shall be provided with an integral four-digit display of the pressure sensed.
   1. Transducer Span: <2 times the design velocity pressure at maximum flow, single range
   2. Accuracy: ±0.25% of full scale, including non-linearity, hysteresis, deadband, and non-repeatability
   3. Temperature Effect: ±0.15% of full scale/°F
   4. Response: 0.5 sec. for 98% of full span change
   5. Overpressure: 5 PSIG Proof
   6. Power: 24VAC/VDC
   7. Analog Output: 0-5VDC, 0-10VDC, or 4-20mA field adjustable
   8. Auto Zero Frequency: every 1 to 24 hours on 1-hour intervals

H. For space or building static pressure monitoring, use Vaisala model SPH10 Static Pressure Head for outside air reference. Mount in location shown on plans or approved by AE.

2.10 DIFFERENTIAL PRESSURE SWITCHES

A. Differential pressure switches shall sense both inlet and outlet of fans and pumps. Device shall be rated for 150% of maximum system pressures that may be encountered. Provide with pressure differential that will be required to meet specified operation and/or to prevent nuisance "toggling" of the device in the system served.

2.11 AIR PRESSURE SAFETY SWITCHES

A. Air pressure safety switches shall be a differential pressure switch that will sense differential, negative, or positive pressure as required by the sequence of operation specification. Device shall be rated for a minimum of 150% of maximum system pressures that may be encountered. Provide with pressure range that will be required to meet specified operation in the system served. Provide with a normally closed contact that will open above setpoint and will not close until the manual reset button is depressed. Setpoint shall be manually adjustable.

2.12 CURRENT STATUS SWITCHES

A. Provide a current sensor with adjustable threshold and digital output with LED display, equal to a Veris model H-708/H-904. Threshold adjustment must be by a multi-turn potentiometer or set by multiprocessor that will automatically compensate for frequency and amperage changes associated with variable frequency drives. When used on variable speed motor applications, use a current sensor that will not change state due to varying speeds.

2.13 POWER SUPPLIES

A. Provide all required power supplies for transducers, sensors, transmitters and relays. All low voltage transformers shall have a resettable secondary circuit breaker and be listed as class 2 power supplies.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install system with trained mechanics and electricians employed by the control equipment manufacturer or an authorized representative of the manufacturer. Where installing contractor is an authorized representative of the control manufacturer, such authorization shall have been in effect for a period of no less than three years.

B. Install all control equipment, accessories, wiring, and piping in a neat and workmanlike manner. All control devices must be installed in accessible locations. This contractor shall verify that all control devices furnished under this Section are functional and operating the mechanical equipment as specified in Section 23 09 93 – Sequence of Operations for HVAC Controls.

C. Label all control devices with the exception of dampers, valves, and terminal unit devices with permanent printed labels that correspond to control drawings. Temperature control junction and pull boxes shall be identified utilizing spray painted green covers. Other electrical system identification shall follow the Division 26 identification specification requirements.

D. All control devices and electrical boxes mounted on insulated ductwork shall be mounted over the insulation. Provide mounting stand-offs where necessary for adequate support. Cutting and removal of insulation to mount devices directly on ductwork is not acceptable. This contractor shall coordinate with the insulation contractor to provide for continuous insulation of ductwork.

E. Mounting of electrical or electronic devices shall be protected from weather if the building is not completely enclosed. This Contractor shall be solely responsible for replacing any equipment that is damaged by water that infiltrates the building if equipment is installed prior to the building being enclosed.

F. Provide all electrical relays and wiring, line and low voltage, for control systems, devices and components. Install all high voltage and low voltage wiring (includes low voltage cable) in metal conduit, Electrical Non-metallic Tubing (ENT), or Electrical Metallic Tubing (EMT), as scheduled below and hereafter referred to generically as conduit. See Wire and Air Piping Conduit Installation Schedule below for specific conduit or tubing to be used. All conduit must be installed in accordance with electrical sections (Division 26) of this specification and the National Electrical Code.

G. Conduit shall be a minimum of 1/2 " for low voltage control provided the pipe fill does not exceed 40%.

H. Minimum low voltage wiring gauge to be 18 AWG for outputs and 20 AWG for inputs. All low voltage wiring to be stranded.

I. Low voltage wiring can be run without conduit above accessible lay-in tile ceilings. All wiring in mechanical rooms, above inaccessible hard ceilings, exterior locations, and in any exposed areas, and in all other locations should be in conduit. Wire for wall sensors must be run in conduit. Wiring for radiation valves shall be run in conduit where routed through walls.

J. Where wiring is installed free-air, installation shall consider the following:
   1. Wiring shall utilize the cable tray wherever possible.
   2. Wiring shall run at right angles and be kept clear of other trades work.
   3. Wiring shall be supported utilizing "J" or "Bridal-type" steel mounting rings anchored to ceiling concrete, piping supports, walls above ceiling or structural steel beams. Mounting rings shall be of open design (not a closed loop) to allow additional wire to be strung without being threaded through the ring. For mounting rings that do not completely surround the wire, attach the wire to the mounting ring with a strap.
   4. Supports shall be spaced at a maximum 4-foot interval unless limited by building construction. If wiring "sag" at mid-span exceeds 6-inches; another support shall be used.
   5. Wiring shall never be laid directly on the ceiling grid or attached in any manner to the ceiling grid wires.
   6. Wall penetrations shall be sleeved.

K. Wiring shall not be attached to existing cabling, existing tubing, piping, ductwork, ceiling supports or electrical or communications conduit.

L. Control panels serving equipment fed by emergency power shall also be served by emergency power.

M. This contractor shall be responsible for all 120VAC power, not provided in the Division 26 specifications, required for equipment provided under this section.

N. Provide communication trunk wiring to integrated devices (i.e. VFD’s, Flow Meters, Chillers, Lighting Panels, Electrical Meters, etc.) that are specified to be connected to the building automation system. Communication trunk wiring shall be as required by the equipment specified under the Section 23 09 23 – Direct Digital Control System for HVAC and shall be routed to the DDC panel designated for that equipment as shown on the plans or the closest DDC panel if not designated. If communication trunks required daisy chained style wiring, provide two communication cables to the DDC panel so that the communication trunk is not dead ended.

O. Install "hand/off/auto" selector switches on systems where automatic interlock controls are specified and "hand/off/auto" selector switches are not supplied with the equipment controlled. Control panel power will not be required for “hand” switch to operate. When switch is in "hand" position, allow manual operation of the selected device without operating the interlocked motors but allowing all unit safety devices to stay in the circuit.
P. All pneumatic tubing and electrical wiring are to be permanently tagged or labeled within one inch of terminal strip with a numbering system to correspond with the "Record Drawings".
Q. After completion of installation, test and adjust control equipment. Submit data showing set points and final adjustments of controls.

3.02 WIRE AND AIR PIPING CONDUIT AND TUBING INSTALLATION SCHEDULE

A. The following conduit schedule shall apply to both polyethylene tubing and wire in conduit where conduit is specified for air tubing or wiring. Conduit and tubing referenced below shall meet specifications in Division 26 and as defined below.
B. Conduit other than that specified below for specific applications shall not be used.
C. Underground Installations within Five Feet (1.5 m) of Foundation Wall: Rigid steel conduit.
D. Underground Installations More than Five Feet (1.5 m) From Foundation Wall: Rigid steel conduit. Plastic-coated rigid steel conduit. Schedule 40 PVC conduit.
E. Under Slab on Grade Installations: Schedule 40 PVC conduit.
F. Exposed Outdoor Locations: Rigid steel conduit.
G. Concealed in Concrete and Block Walls: Rigid steel conduit. Schedule 40 PVC conduit. Electrical Nonmetallic Tubing (ENT).
H. Within Concrete Slab: Rigid steel conduit. Schedule 40 PVC conduit. Electrical Nonmetallic Tubing (ENT).
I. Concealed Dry Interior Locations: Rigid steel conduit. Intermediate metal conduit. Electrical metallic tubing.
J. Exposed Dry Interior Locations: Rigid steel conduit. Intermediate metal conduit. Electrical metallic tubing.

3.03 CONTROL DAMPERS

A. All control dampers furnished by the control manufacturer are to be installed by the Mechanical Contractor under the coordinating control and supervision of the Temperature Control Contractor in locations shown on plans or where required to provide specified sequence of control.
B. Coordinate installation with the sheet metal installer to obtain smooth duct transitions where damper size is different than duct size. Blank off plates will not be accepted. Transitions required to facilitate dampers shall be provided by Mechanical Contractor.
C. Each operator shall serve a maximum damper area of 36 square feet. Where larger dampers are used, provide multiple operators.
D. Furnish control dampers as shown on drawings and/or as required to perform control sequences specified, except those furnished with other equipment.
E. Control dampers furnished by Temperature Control Contractor shall be installed by Mechanical Contractor under coordinating control and supervision of Temperature Control Contractor.

3.04 CONTROL VALVES

A. All temperature control valves furnished by the control manufacturer are to be installed by the Mechanical Contractor under the coordinating control and supervision of the Temperature Control Contractor in locations shown on plans or where required to provide specified sequence of control.

3.05 CONTROL SYSTEM INSTRUMENTATION

A. Install thermometers at each point of temperature transmission (sensors) and control, except reheat coils, unless the drawings indicate a thermometer is to be installed by the piping or Sheetmetal installer. Install thermometers to permit easy reading from the floor or operating platform. Provide remote mounting or swiveled mounting as required for easy reading. Flush mounting where not easily read is not acceptable.

3.06 ROOM THERMOSTATS AND TEMPERATURE SENSORS

A. Check and verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Locate room thermostats and sensors [xxx] inches above floor. Align with light switches and humidistats. For drywall installations, thermostat mounting shall use a back-box attached to a wall stud, drywall anchors are not acceptable.
B. Any room thermostats or sensors mounted on an exterior wall shall be mounted on a thermally insulated sub-base. Subbase to provide a minimum of one-half inch of insulation.
C. Where thermostats or sensors are mounted on exterior walls or in any location where air transfer will affect the measured temperature or humidity seal the conduit and any other opening that will affect the measurement.
D. Provide guards on thermostats in entrance hallways, other public areas, or in locations where thermostat is subject to physical damage.

3.07 LOW LIMIT THERMOSTATS (FREEZESTATS)

A. Install low limit controls where indicated on the drawings or as specified. Unless otherwise indicated, install sensing element on the downstream side of heating coils.
B. Mount units using flanges and element holders. Provide duct collars or bushings where sensing capillary passes through sheet metal housings or ductwork; seal this penetration to eliminate air leakage. Mount the units in an accessible location as to allow for resetting after low limit trips while still meeting manufacturer's installation requirements for proper function.
C. Distribute (serpentine) sensing element horizontally across the coil to cover every square foot of coil; on larger coils this may require more than one instrument. Install controls at accessible location with mounting brackets and element duct collars where required.
D. For integral face and bypass coils the elements are to be run vertically on the face of the heating coil inside the damper enclosure, this will require drilling the frame to run element around the by-pass.

3.08 PRESSURE TRANSDUCERS AND HIGH LIMIT PRESSURE SWITCHES

A. Install capped tees in air piping at air pressure transducers for connection of calibration equipment. Capped tee shall consist of two-inch poly tubing capped with a brass plug. Rubber caps are not acceptable. Install Petes Plugs fittings at each take-off from main piping for liquid pressure transducers for connection of calibration equipment. Install differential pressure transducers for filter monitoring at the filter section of the air handling unless otherwise specified. All other differential or static pressure transducers and differential or static pressure high limit switches for air applications shall be mounted in the temperature control panel serving the equipment being controlled or monitored. All devices mounted on equipment shall be mounted in a location that is at a maximum of five feet above the floor. For steam and liquid applications, provide shutoff valves at piping takeoff points.

3.09 TEMPERATURE CONTROL PANELS

A. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide permanent printed labeling for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
B. Provide as-built control drawings of all systems served by each local panel in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.

3.10 DIFFERENTIAL PRESSURE SWITCHES

A. Provide for each fan or pump specified or shown on control diagrams on drawings. Provide shutoff valves at piping takeoff points. Readjust pressure and/or differential setpoints for proper operation after final balancing is completed.

3.11 CURRENT STATUS SWITCHES

A. Provide for each fan or pump specified or shown on control diagrams on drawings. Set threshold adjustment to indicate belt or coupling loss. Readjust threshold for proper operation after final balancing is completed. Use the variable frequency drive (VFD) integrated relay output for motor status, if provided on the VFD, in lieu of a discrete current switch. A separate current switch provided

under this section shall be wired in parallel with the VFD motor status relay when a bypass starter is provided on the VFD to prove motor status in the bypass mode.

3.12 TRAINING

A. See Section 23 05 00 – Common Work Results for HVAC for general training requirements.

B. Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 2 hours.

C. Provide one training session per shift of building operating engineers at two times:
   1. At the start of the warranty period.
   2. After completion of 9 months of warranty period.

END OF SECTION

SECTION 23 09 23
DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 **– GENERAL**

1.01 **SCOPE OF WORK**

A. The work associated with this section WILL be bid as part of the Division 23 scope of work.

1.02 **SECTION INCLUDES**

A. Work in this section includes Direct Digital Control (DDC) panels, main communication trunk, software programming, and other equipment and accessories necessary to constitute a complete Direct Digital Control (DDC) system. This system interfaced with pneumatic/electric controls (Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC) utilizing Direct Digital Control signals to operate actuated control devices shall meet, in every respect, all operational and quality standards specified herein.
   1. Local Control Panels
   2. Direct Digital Controls (DDC)
   3. Networking/Communications
   4. BACnet Requirements
   5. Supervisory Controllers
   6. System Software Features
   7. Programmable Controllers
   8. Application Specific Controllers - HVAC
   9. Operator Interface Requirements
   10. Operator Workstation & DDC Server
   11. Web Based HTML Interface
   12. Portable Operator Terminal
   13. ASC Portable Service Terminal

B. Provide all labor and software updates required so that the manufacturer's current software is provided for a period of 3 years after date of substantial completion.

C. Provide graphic-based displays for all systems.

1.04 **RELATED WORK**

A. Applicable provisions of Division 1 govern work under this section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC - Coordination
D. Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC
E. Section 23 09 93 – Sequence of Operation for HVAC Controls
F. Division 23 – HVAC - Equipment provided to be controlled or monitored
G. Division 26 – Electrical - Equipment provided to be controlled or monitored

1.05 **SUBMITTALS**

A. Refer to Section 23 05 00 – Common Work Results for HVAC, Submittals. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. DDC Controls

B. Include the following information:

C. Details of construction, layout, and location of each temperature control panel within the building, including instruments location in panel and labeling. Indicate which piece of mechanical equipment is associated with each controller and what area within the building is being served by that equipment. For terminal unit control, provide a room schedule that lists mechanical equipment tag, room number of spaces served, address of DDC controller, and any other pertinent information required for service.

D. Product Data: Submit manufacturer's specifications for each control device furnished, including installation instructions and startup instructions. General catalog sheets showing a series of the same device is not acceptable unless the specific model is clearly marked. Annotated software program

documentation shall be submitted for system sequences, along with descriptive narratives of the sequence of operation of the entire system involved. Submit wiring diagram for each electrical control device along with other details required to demonstrate that the system has been coordinated and will function as a system.

E. Maintenance Data: Submit maintenance data and spare parts lists for each control device. Include this data in maintenance manual.

F. Record Drawings: Prior to request for final payment provide complete composite record drawings to incorporate the DDC and Pneumatic/Electric fieldwork. All software addressing for device communication shall be noted for all devices provided under this section and the communication addressing required for devices provided by others that are integrated into the direct digital control system provided under this section. Coordinate with the supplier of the equipment specified to be interfaced through digital communications for communication addressing. Provide circuit number of 120VAC panel power circuit(s) feeding each control panel on record drawings. Label circuit number(s) inside the panel served.

1.06 **FUNCTIONAL TESTS**

A. Refer to Section 23 05 00 – Common Work Results for HVAC, Functional Tests. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, perform the following function tests:
   1. DDC Controls

1.07 **REFERENCE STANDARDS**

A. FCC Part 15, Subpart J, Class A - Digital Electronic Equipment to Radio Communication Interference

1.08 **QUALITY ASSURANCE**

A. Manufacturers: Installer: CBRE-ESI 3410 Gateway Rd, Brookfield, WI 53045-5115; Mechanical Technologies Inc, 701 Morley Rd, Green Bay, WI 54303

C. Response Time: During warrantee period, four (4) hours or less, 24-hours/day, 7 days/week.

D. Electrical Standards: Provide electrical products, which have been tested, listed and labeled by Underwriters' Laboratories (UL) and comply with NEMA standards.

E. DDC Standards: DDC manufacturer shall provide written proof with shop drawings that the equipment being provided is in compliance with FCC rules governing the control of interference caused by Digital Electronic Equipment to Radio Communications (Part 15, Subpart J, Class A).

1.09 **OPERATION AND MAINTENANCE DATA**

A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 – Common Work Results for HVAC.

B. In addition to the general content specified in Section 23 05 00 – Common Work Results for HVAC, supply the following additional documentation:

1.10 **DELIVERY. STORAGE AND HANDLING**

A. Provide factory-shipping cartons for each piece of equipment and control device. This contractor is responsible for storage of equipment and materials inside and protected from the weather.

PART 2 **– PRODUCTS**

2.01 **GENERAL**

A. Provide DDC control products in sizes and of capacities as required, conforming to manufacturer's standard materials and components as published in their product information, designed and constructed as recommended by the manufacturer and as required for application indicated.

B. System shall be capable of operating with 120 VAC power supply, fully protected with a shutdown-restart circuit, and associated hardware and software.

C. Shall be Niagara N4 network controller, Distech – BacNet application specific controller.

2.02 **LOCAL CONTROL PANELS**

A. Use control panels with suitable mounting brackets for each supply fan system. Locate panel adjacent to system served.
B. Fabricate panels of 14-gauge furniture grade steel or 6063-T5 extruded aluminum alloy, totally enclosed on six sides, hinged door and keyed lock, with manufacturer's standard shop painted finish and color.
C. Provide UL listed cabinets for use with line voltage devices.
D. Plastic control enclosures will be approved provided all conduits are bonded and grounded.
E. Provide control panels for all DDC Controllers, ASC's and associated function modules. All controls to be in panels except for terminal unit controllers mounted within the terminal unit equipment enclosure or VAV box controllers designed to be directly mounted on air terminals. Provide terminal unit equipment enclosures with removable cover for all terminal units located in exposed ceilings that completely enclose the DDC controller and allow for conduit terminations.
F. Permanently label all controls; tag all control wiring.

2.03 **DIRECT DIGITAL CONTROLS**

A. System to be capable of integrating multiple building functions, including equipment supervision and control, alarm management, energy management, and trend data collection.
B. DDC to consist of Supervisory Controllers, Programmable Controllers, stand-alone Application Specific Controllers (ASC's), Operators Terminals, Operator Workstations, DDC system servers, and other operator interface devices.
C. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, ASC's, and operator devices.
D. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

2.04 **NETWORKING/COMMUNICATIONS**

A. The design of the DDC shall be networked. The highest-level networking shall use Ethernet and the sub-level networking shall use serial communications. Inherent in the system's design shall be the ability to expand or modify the highest network either via a local area network (LAN), wide area network (WAN), or a combination of the two schemes.
B. The highest level DDC communications network shall be capable of direct connection to and communication with a high-speed LAN or WAN utilizing an Ethernet connection. Communication protocol used shall be BACnet/IP.
C. The supervisory controller shall directly oversee a local network such that communications may be executed directly to and between programmable controllers and ASC's. All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all points and application reports on the network.
D. Provide serial communication ports on all ASC's for operator's terminal communications with the DDC Controller.
E. Access to system data shall not be restricted by the hardware configuration of the DDC system.
F. Global data sharing or global point broadcasting shall allow point data to be shared between programmable controllers and ASC's when it would be impractical to locate multiple sensors.
G. Network design shall include the following provisions:
    1. Data transfer rates for alarm reporting and quick point status from multiple programmable controllers and ASC's. The minimum baud rate shall be 9600 baud.
    2. Support of any combination of programmable controllers and ASC's. A minimum of 32 programmable controllers and ASC's shall be supported on a single local network. The buss shall be addressable for up to 32 ASC's.
    3. Detection of single or multiple failures of programmable controllers and ASC's or the network media.
    4. Error detection, correction, and re-transmission to guarantee data integrity.
    5. Use commonly available, multiple-sourced, networking components.
    6. Use of an industry standard communication transport, such as ARCNET, Ethernet, and IEEE RS-485 communications interface.

2.05 **BACNET REQUIREMENTS**

A. BACnet of highest-level network communications will utilize BACnet/IP over Ethernet.
B. Supervisory controllers shall provide a Protocol Implementation Conformance Statement (PICS) and BACnet Interoperability Building Blocks (BIBB'S) as required by the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ANSI/ASHRAE) Standard 135-2001, BACnet protocol.
C. In general, all highest level networked supervisory devices shall support the following:
    1. Segmentation Capability
    2. Segmentation requests supported
    3. Segmentation responses supported
D. Standard Object Types Supported:
    1. Analog input
    2. Analog output
    3. Analog value
    4. Binary input
    5. Binary output
    6. Binary value
    7. Calendar
    8. Device
    9. Event enrollment
    10. Group
    11. Multistate input
    12. Multistate output
    13. Multistate value
    14. Notification class
    15. Schedule
E. Data Link Layer Option
    1. BACnet Internet Protocol (IP) (Annex J)
F. Networking Options
G. BACnet/IP Broadcast Management Device (BBDM)
H. Character Sets supported
    1. ANSI X3.4
    2. ISO 10646 Universal Character Set-2

2.06 **SUPERVISORY CONTROLLERS**

A. Supervisory controllers shall be microprocessor-based, multi-tasking, multi-user and digital control processors and shall be a Niagara N4 controller.
B. Each supervisory controller shall have sufficient memory to support its own operating system and databases including:
    1. Control processes
    2. Energy management application
    3. Alarm management
    4. Trend data
    5. Maintenance support applications
    6. Operator I/O
    7. Dial-up communications
    8. Manual override monitoring
C. The system shall be modular in nature and shall permit easy expansion through the addition of field controllers, sensors, and actuators.
D. Supervisory controllers shall provide at least two RS-232C, USB serial communication ports, or Ethernet ports for simultaneous operation of multiple operator I/O devices, such as laptop computers, personal computers, and video display terminals.
E. Supervisory controllers shall monitor the status of all overrides and include this information in the logs and summaries to inform the operator that automatic control has been inhibited.
F. Each supervisory controller shall continuously perform self-diagnostics, communications diagnostics, and diagnostics of all subsidiary equipment. Supervisory controllers shall provide both local and

remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each supervisory controller.

G. Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high to allow all signal wiring to be run in the same conduit as high voltage wiring acceptable by electrical code.

H. In the event of the loss of normal power, there shall be an orderly shutdown of the supervisory controller to prevent the loss of data base or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

I. Upon restoration of normal power, the supervisory controller shall automatically resume full operation without manual intervention.

J. Should supervisory controller memory be lost for any reason, the supervisory controller shall have the capability of reloading its programming via high speed local area network from the control system archive workstation or server, the local RS-232C port, or telephone line dial-in.

2.07 **SYSTEM SOFTWARE FEATURES**

A. All necessary software to form a complete operating system, as described in this specification, shall be provided as an integral part of the supervisory controller, and shall not be dependent upon higher level computer for execution.

B. Control software shall include a provision for limiting the number of times that each piece of equipment may be cycled within any one-hour period.

C. The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

D. Supervisory controllers shall have the ability to perform any or all of the following energy management routines:
   1. Time of day scheduling
   2. Calendar based scheduling
   3. Holiday scheduling
   4. Optimal start
   5. Optimal stop
   6. Demand limiting
   7. Load rolling
   8. Heating/cooling interlock

E. All programs to be executed automatically without the need for operator intervention and be flexible enough to allow user customization. Programs shall be applied to building equipment described in Section 23 09 93 – Sequence of Operations for HVAC Controls of this specification.

F. Supervisory controllers shall be able to execute configured processes defined by the user to automatically perform calculations and control routines.

G. It shall be possible to use any of the following in a configured process:
   1. Any system-measured point data or status
   2. Any calculated data
   3. Any results from other processes
   4. Boolean logic operators (and, or)

H. Configured processes may be triggered based on any combination of the following:
   1. Time of day
   2. Calendar date
   3. Other processes
   4. Events (e.g., point alarms)

I. A single process shall be able to incorporate measured or calculated data from any and all other ASC's.

J. A single process shall be able to issue commands to points in any and all other programmable controllers and ASC's on the local network.

K. Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each supervisory controller shall perform distributed, independent alarm analysis and filtering to minimize network traffic and prevent alarms from being lost. At no time shall the

ability of supervisory controllers to report alarms be affected by either operator activity at the local I/O device or communications with other ASC's on the network.

L. All alarm or point change reports shall include the English language description of each point and the time and date of the occurrence.

M. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Users shall have the ability to manually inhibit alarm reporting for each point.

N. The user shall also be able to define conditions under which point changes need to be acknowledged by an operator and/or logged for analysis at a later date.

O. Alarms reports and messages shall be directed to an operator device.

P. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 60-character alarm message to more fully describe the alarm condition or direct operator response.

Q. Each supervisory controller shall be capable of storing a library of at least 100 messages. Each message may be assignable to any number of points in the panel.

R. A data collection utility shall be provided to automatically sample, store, and display system data.

S. Measured and calculated analog and binary data shall be assignable to user definable trends for the purpose of collecting operator specified performance data over extended periods of time. Sample intervals of 1 minute to 24 hours, in one minute or one-hour intervals, shall be provided. Each supervisory controller shall have a dedicated buffer for trend data and shall be capable of storing 16 trend logs. Each trend log shall have up to four points trended at 48 data samples each. Data shall be stored at the supervisory controller and up-loaded to the DDC system server when archiving is desired.

T. Supervisory controllers shall automatically accumulate and store runtime hours for binary input and output points specified in Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC.

U. Supervisory controllers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis, user defined, for user-selected analog and binary pulse input type points.

V. Totalization shall provide calculation and storage accumulations of up to 9,999,999 units (e.g., KWH, gallons KBTU, tons, etc.).

W. The totalization routine shall have a sampling resolution of one minute.

X. The user shall have the ability to define a warning limit. Unique, user specified messages shall be generated when the limit is reached.

Y. Supervisory controllers shall have the ability to count events, such as the number of times a pump or fan system is cycled on and off.

Z. The event totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.

2.08 PROGRAMMABLE CONTROLLERS

A. Programmable controllers shall be provided with a software program that shall allow the user to design flexible software algorithms for the control sequences as described in Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC and Section 23 09 93 – Sequence of Operation for HVAC Controls.

B. Programmable controllers shall support all necessary point inputs and outputs to perform the specified control sequence in a totally stand-alone fashion.

C. Each programmable controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

D. Each programmable controller shall support the use of a locally mounted status and adjust panel interface to allow for the local adjustment of all setpoints, temporary override of any input or output points and status of all points directly at the controller. The capabilities of the locally mounted status and adjust panel shall include, but not be limited to, the following:

1. Display temperatures
2. Display status
3. Display setpoints
4. Display control parameters
5. Override binary output control

6. Override analog output control
7. Override analog setpoints
8. Modification of gain and offset constants

E. All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the programmable controller.

F. Programmable controllers shall support, but not be limited to, the following configurations of systems to address current requirements as described in Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC and Section 23 09 93 – Sequence of Operation for HVAC Controls and for future expansion of air handling units:
1. Roof top air handling units
2. Boiler plants with pump logic
3. Generic system interlocking through hardware

2.09 APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

A. Each supervisory controller shall be able to extend its monitoring and control through the use of stand-alone application specific controllers (ASC's) and shall be Distech Controls.

B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and databases including:
1. Control Processes
2. Energy Management Applications
3. Operator I/O (Portable Service Terminal)

D. The operator interface to any ASC point or program shall be through the supervisory controller connection to any ASC on the network.

E. ASC's shall directly support the temporary use of a portable service terminal that can be connected to the ASC via zone temperature or directly at the controller. The capabilities of the portable service terminal shall include, but not be limited to, the following information for the ASC:
1. Display temperatures
2. Display status
3. Display setpoints
4. Display control parameters
5. Override binary output control
6. Override analog output control
7. Override analog setpoints
8. Modification of gain and offset constants

F. All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the ASC.

G. ASC’s shall support, but not be limited to, the following configurations of systems to address current requirements as described in Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC and Section 23 09 93 – Sequence of Operation for HVAC Controls portions of this specification, and for future expansion of air handling units:
1. Variable Air Volume Terminals
2. Reheat Terminals
3. Packaged Air Handling Units

2.10 OPERATOR INTERFACE REQUIREMENTS

A. Command Entry/Menu Selection Process: Operator interface software shall minimize operator training through the use of English language prompting and English language point identification.

B. Text-Based Displays: The operator interface shall provide consistent text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application-naming conventions shall be the same at all operator devices.

C. Graphic-Based Displays: The operator interface shall include graphic based displays of each system on DDC systems that currently employ graphic based displays. The point data associated with each system shall dynamically update at a minimum of every 30 seconds. Graphic displays shall have the

ability to be linked to each other to provide a "drill down" capability from main graphic displays to more specific system-based displays. Provide a building level graphic display that links to system graphics. For systems that have ASC controlled terminal unit controls, provide a building floor plan with dynamic temperatures shown on the graphic that can be drilled into for more specific terminal information. Points provided in the graphic shall have the override and adjust capability specified under operator commands.

D. Password Protection:
   1. Multiple-level password access protection shall be provided to allow the user/manager to limit control, display, and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.
   2. Passwords shall be exactly the same for all operator devices.
   3. A minimum of three levels of access shall be supported:
      a. Level 1 = Data access and display
      b. Level 2 = Level 1 + operator overrides and commands
      c. Level 3 = Level 2 + database generation and modification
   4. A minimum of 4 passwords shall be supported at each supervisory controller.
   5. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device shall be limited to only those items defined for the access level of the password used to log-on.
   6. Provide user definable, automatic log-off timers of from 1 to 60 minutes to prevent operators from inadvertently leaving devices on-line.

E. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:
   1. Start-up or shutdown selected equipment
   2. Adjust setpoints
   3. Override analog and binary outputs
   4. Add/modify/delete time programming
   5. Enable/disable process execution
   6. Lock/unlock alarm reporting for each point
   7. Enable/disable totalization for each point
   8. Enable/disable trending
   9. Enter temporary override schedules
   10. Define holiday schedules
   11. Change time/date
   12. Enter/modify analog alarm limits
   13. Enable/disable analog alarm limits
   14. Enable/disable demand limiting
   15. Enable/disable duty cycle

F. Logs and Summaries: Reports shall be generated manually and directed to the displays. As a minimum, the system shall allow the user to easily obtain the following general listing of all points in the system, which shall include, but not be limited to:
   1. Points currently in alarm
   2. Off-line points
   3. Points currently in override status
   4. Points in weekly schedules
   5. Holiday programming

G. Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration on the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

H. System Configuration and Definition:
   1. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
   2. The system shall be provided complete with all equipment, software, and documentation necessary to allow an operator to independently perform the following functions:

a. Add/delete/modify application specific controllers
b. Add/delete/modify points of any type, and all associated point parameters, and tuning constants
c. Add/delete/modify alarm reporting definition for each point
d. Add/delete/modify energy management applications
e. Add/delete/modify time and calendar-based programming
f. Add/delete/modify totalization for every point
g. Add/delete/modify historical data trending for every point
h. Add/delete/modify configured control processes
i. Add/delete/modify dial-up telecommunication definition
j. Add/delete/modify all operator passwords
k. Add/delete/modify alarm messages

I. Network Wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single programmable controller or ASC but shall be able to include data from any and all other programmable controller or ASC's to allow the development of network-wide control strategies.

J. System Definition/Control Sequence: All portions of system definition shall be self-documenting and capable of providing hardcopy printouts of all configuration and application data.

K. Data Base Save/Restore/Back-Up: Backup copies of all programmable controller, ASC and supervisory controller databases shall be stored in at least one personal computer or laptop. Users shall also have the ability to manually execute downloading of a programmable controller, ASC or supervisory controller database.

2.11 **WEB BASED HTML BROWSER INTERFACE**

A. Provide a HTML based browser interface (Web Server) for accessing the DDC system. This shall include all hardware and software to provide an Ethernet twisted pair connection to the owners local or wide area network (LAN or WAN) that can be used to access the DDC system through a standard internet browser.

B. All information shall be provided to the owner's IT staff to facilitate connection through the owner's LAN/WAN.

C. At a minimum, this interface shall be capable of all functions described under the Operator Interface section, Password Protection, Operator Commands, and Logs and Summary subsections of this specification.

2.12 **ASC PORTABLE SERVICE TERMINAL**

A. Provide a portable service terminal capable of interfacing to ASC's through a local serial port located on the ASC or if a remote thermostat is provided, at the thermostat. This terminal shall be capable of displaying all input and output points, adjusting all setpoints, and adjusting all tuning parameters for the ASC. This device is primarily for setup and servicing of ASC's.

PART 3 **– EXECUTION**

3.01 **GENERAL**

A. This contractor shall provide all labor, materials, engineering, software permits, tools, check-out and certificates required to install a complete DDC system as herein specified.

3.02 **INSTALLATION**

A. All work and materials are to conform in every detail to the rules and requirements of the National Electrical Code and present manufacturing standards. All wiring and cable installation shall conform with the wiring installation as specified in the installation section of Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC. All material shall be UL approved.

B. Install system and materials in accordance with manufacturer's instructions, rough-in drawings and details on drawings.

C. Line voltage wiring to power the DDC Controllers, not provided by the Division 26 contractor, to be by this contractor.

D. Control panels serving equipment fed by emergency power shall also be served by emergency power.

E. Provide uninterruptable power supplies where necessary to provide proper startup of equipment or to accomplish power restart control sequences specified.
F. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide printed plastic tags for instruments and controls inside cabinet and on engraved plastic nameplates cabinet face.
G. Provide as-built control drawings of all systems served by each local panel in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.
H. Where a new system is required to be extended to an existing owner Building Automation Network (BAN) (typically connected via the owner's Local Area Network (LAN) or Wide Area Network (WAN)), extension of the data-net between DDC Controllers and to the BAN to be by this contractor.
I. Provide all necessary routers and or repeaters to accomplish connection to the LAN via the panel-mounted port provided.
J. Provide two data jacks in control panels housing supervisory controllers and allocate 6"x6" for each data jack in the panel. The first jack will be used for connecting the supervisory controller to the Building Automation Network (BAN). The second jack will be used as a spare for connecting to the BAN by service personnel.
K. All cables to the DDC panels shall be extended in the DDC panel with sufficient spare cable (minimum of 5') to allow termination.

3.03 **TRAINING**

A. See Section 23 05 00 – Common Work Results for HVAC for general training requirements.
B. Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 2 hours.
C. Provide two follow-up visits for troubleshooting and instruction, one six months after substantial completion and the other at the end of nine months of warranty period. Length of each visit to be not less than 2 hours or the time necessary to provide required information and complete troubleshooting and inspection activity for all controls installed under this section. Coordinate the visit with the owner and provide an inspection report to the owner of any deficiencies found.

END OF SECTION

SECTION 23 09 93
SEQUENCE OF OPERATION FOR HVAC CONTROLS

PART 1 – GENERAL

1.01 SCOPE OF WORK
A. Base Bid: Unless noted otherwise, the Mechanical Contractor shall provide all labor and materials for a complete control system in this specification.

1.02 SECTION INCLUDES
A. This section includes control sequences for HVAC equipment as well as equipment furnished by others that may need monitoring or control. Included are the following topics:
   1. General Control Sequence Items
   2. Terminal Unit Control – DDC and Electric
   3. Hot Water Unit Heater Control-DDC Control
   4. Hot Water Unit Heater Control-Electric Control 2-Way TCV
   5. Hot Water Unit Heater Control-Electric Control
   6. Variable Volume Air Terminal Unit with Reheat Control
   7. Variable Volume Roof Top Air Handling Unit Control

1.03 RELATED WORK
A. Applicable provisions of Division 1 govern work under this Section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 14 – Variable Frequency Drives
D. Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC – Coordination
E. Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC
F. Section 23 09 23 – Direct Digital Control System for HVAC
G. Division 23 – HVAC - Equipment provided to be controlled or monitored

1.04 SUBMITTALS
A. Refer to Division 1, Section 23 05 00 – Common Work Results for HVAC, Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC and Section 23 09 23 – Direct Digital Control System for HVAC for descriptions of what should be included in the submittals.
B. Provide a complete narrative of the sequence of operations for equipment that is controlled through the DDC system. Provide a complete narrative of the sequence of operation for equipment that is controlled directly from that equipment (without control logic through the DDC system). The narrative of the sequence of operation shall not be a verbatim copy of the sequences contained herein but shall reflect the actual operation as applied by the contractor.

1.05 DESIGN CRITERIA
A. Reference Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC.

1.06 OPERATION AND MAINTENANCE DATA
A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 – Common Work Results for HVAC.

1.07 REFERENCE
A. For the following work, refer to Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC.
   1. Furnishing and installing all field devices, including electronic sensors for the DDC of this section, equipment, and all related field wiring, interlocking control wiring between equipment, pneumatic tubing, sensor mounting, etc., that is covered in that section.
   2. Motorized control dampers and actuators, thermowells (temperature sensing wells), automatic control valves and their actuators.

1.08 DESCRIPTION OF WORK

A. Control sequences are hereby defined as the manner and method by which automatic controls function. Requirements for each type of operation are specified in this section.

B. Operation equipment, devices and system components required for automatic control systems are specified in other Division 23 control sections of these specifications.

C. All temperature, humidity, and pressure sensing, and all other control signal transportation for the control sequences shall be furnished under Section 23 09 14. All pneumatic, electronic, and electric input/output signals shall be extended under Section 23 09 14, with adequate lead length for termination within the appropriate control panel being provided under Section 23 09 23.

D. Sequences for equipment controlled by Direct Digital Controls (DDC) as specified are accomplished by hardware and software provided under Section 23 09 23. Sequences for equipment controlled by pneumatic or electric self-contained controls are accomplished by hardware provided under Section 23 09 14.

PART 2 – PRODUCTS

2.01 Not applicable to this section – reference Sections 23 09 23 and 23 09 14 for product descriptions.

PART 3 – EXECUTION

3.01 CONTROL SEQUENCES

A. General Control Sequence Items:

1. Setpoints:

a. All setpoints indicated in the control specification are to be adjustable. The setpoints shall be readily available to be modified in the mechanical system software system summary (either textual or graphic based) and under the same software level as hardware points. Some less used setpoints may be provided on a lower software level, if requested by the Owner for clarity. The setpoints indicated herein are only specified as a calculated starting point (or initial system operation). It is expected that setpoint adjustments and control loop tuning shall be required to provide optimum system operation based on requirements of the building. The control contractor shall work with the balancing contractor and the Owner to provide the final system setpoint adjustments and control loop tuning after the system is in operation and building is in use. Document all final setpoints on the as-built control drawings. Any questions regarding the intended operation of the HVAC equipment and control systems shall be referred to the HVAC design engineer through the appropriate construction communication process. The following setpoints should be used as initial setpoints unless otherwise specified in the individual control sequences:

1) Occupied Space Terminal Unit Heating: TBD
2) Occupied Space Terminal Unit Cooling: TBD
3) Entry Way Heating: TBD
4) Mechanical or Unoccupied Space Cooling/Ventilation: TBD
5) Mechanical or Unoccupied Space Heating: TBD

B. Anti-Cycling:

1. When HVAC equipment or a sequence is specified to be started and stopped by a temperature, humidity, pressure setpoint or any other controlled variable, there shall be an adjustable differential setpoint that shall be set to prevent short cycling of the systems and equipment due to minor changes in the controlled variable. Temperature differential setpoints shall be set at 2º F and non-temperature setpoints shall be set at 10% of the controlled range unless otherwise specified. Setpoints shall indicate at when the process should be turned on. Heating and cooling differentials shall be set for above setpoint and will be used to turn the process off. For example, an economizer sequence called to switch at 68º F, would turn on at 68º F and off at 70º F since it is a cooling function. A heating lockout setpoint of 50º F would turn on heating control at 50º F and off at 52º F Non-temperature differentials shall be set above setpoint if the setpoint is indicating a minimum value or below setpoint if the setpoint is indicating a maximum value. Provide

minimum runtime timers for loads that are cycled to prevent over-cycling. Timers shall be set as specified or as needed to prevent damage or excessive wear to the equipment. Unless otherwise specified in the individual control sequences, fans and pumps shall have a minimum runtime on timers of 15 minutes (adj.) and off timers of 5 minutes (adj.). Safeties shall override runtime timers.

C. Deadbands:
   1. Provide deadbands for all DDC control loops to prevent constant hunting of output signals to controlled devices. Deadbands shall be set to provide adequate control around setpoint as follows unless otherwise specified in the individual control sequences:
      a. Temperature Control: ±0.5º F
      b. Humidity Control: ±1% RH
      c. Airflow Control: ±2% of total flow
      d. AHU Static Pressure Control: ±0.01 in. w.c.

D. Alarms: Provide all alarmed points with adjustable time delays to prevent nuisance tripping under normal operation and on equipment start-up. For all commanded outputs that have status feedback, provide an alarm that will indicate the commanded output is not in its commanded state. Provide alarms on all points as indicated on point charts. For existing automations systems, add/delete what is called for on the point charts after consultation with Owner to provide consistent alarming throughout the automation system.

E. Equipment Start/Stop Failure States: All start/stop points for equipment shall utilize normally open contacts unless called out specifically in the individual control sequences.

F. Lead/Lag Sequencing: For sequences that call for lead/lag of equipment connected to building automation systems, the lead device shall be able to be chosen through a selectable day of the week and time of day through the building automation system. Coordinate with the Owner for scheduling switchover and frequency. Unless otherwise directed, switchover shall occur at 10AM Tuesday and shall rotate the lead device on a weekly cycle rotating through all devices sequentially. For standalone lead/lag sequence controllers (non-DDC), the lead device shall be selected by a switch on the panel face.

G. Variable Frequency Drive (VFD) Motor Run Status: Use the VFD programmable relay dry contact output specified to be provided with the VFD under Section 23 05 14 – Variable Frequency Drives to prove motor run status and detect belt loss or coupling break. If a bypass contactor is provided with the VFD, provide an adjustable current switch and wire it in parallel with the VFD output for proving motor status.

H. VFD Bypass & Safety Interlocks: VFD's equipped with bypass starters shall be interlocked so that the start/stop and safety circuits that are called out for VFD operation shall be functional when the VFD is indexed to the bypass starter mode. Unless otherwise specified in the sequence below, the switch from inverter to bypass starter modes shall be through a manual switch provided on the VFD/bypass starter package.

I. VFD Minimum Speed & Ramp Timers: The VFD start-up technician shall work with the DDC Temperature Control Contractor to determine the minimum speed required for the motor controlled by the VFD to provide cooling of the motor as installed to prevent heat related problems. This minimum speed shall be set in the VFD controller. The VFD start-up technician shall work with the DDC Temperature Control Contractor to set the acceleration and deceleration timers in the VFD controller at 30 seconds for motors less than 40 HP and 60 seconds for motors 40 HP and greater.

J. Current Switch Setup: When current switches are used for proving fan or pump status, they shall be set up so that they will detect belt or coupling loss by the reduction in current draw on loss of coupled load. The current switch set up shall be redone by the Temperature Control Contractor after the balancer is complete.

K. Damper Interlocks for Fans with Starters: For fan systems with magnetic starters and shutoff dampers specified with end switches, the damper interlock shall be hardwired in such a way that the damper shall open if the fan starter hand / off / auto switch is in the hand or in the auto position and being called to start. After the damper end switch has proven the damper open, a hardwire interlock from the end switch to the starter holding coil for the fan shall cause the fan to start. For fan systems that are ducted in parallel, see specific sequence for fan system on interlock requirements.

L. Damper Interlocks for Fans with VFD's:

1. For fan systems with VFD's and shutoff dampers specified with end switches, the damper end switches shall be hardwired interlocked to the safety circuit(s) of the VFD to prevent the fan from starting until the damper is proven open. This interlock shall prevent the fan from running in either the VFD or bypass (if provided) mode. The damper end switch shall also be monitored by the DDC system. For fan systems that are ducted in parallel, see specific sequence for fan system on additional interlock requirements.
2. For fan systems with VFD's and shutoff dampers specified with end switches, hardwire interlock the shutoff damper with the fan VFD. When the fan is remotely or locally commanded to start, VFD contacts shall energize outside air damper actuator to open damper. The damper position end switch shall be wired to run permissive input on the VFD and enable the VFD to start when the damper position end switch provides the damper is open. This operation shall be provided for VFD and bypass operation if the VFD is provided with a bypass. The damper end switch shall also be monitored by the DDC system. For fan systems that are ducted in parallel, see specific sequence for fan system on additional interlock requirements.

M. Fan Interlocking:
1. Provide interlocks between supply and return or exhaust fan systems as scheduled on the plans or called out in individual control sequences. If DDC controlled, interlocks shall be done through DDC start/stop points unless otherwise specified in individual control sequences. If not DDC controlled, interlocks shall be accomplished via hardwire interlocks between fan starters or VFD's.

N. Thermostats and Sensors: All devices and equipment including terminal units, specified to be controlled in a control sequence by a thermostat or sensor, shall be provided with a thermostat or sensor, whether or not the device is indicated on the plans. Consult the HVAC design engineer for the thermostat or sensor location.

O. Original Equipment Manufacturer (OEM) Controller Ddc Integration:
1. Provide DDC programming to define all equipment integral input/output points, setpoints, data points, calculations, etc. that are available through the manufacturer's communication interface. Consult with the Owner DDC operations personnel to determine if some of the points should be omitted (for clarity or lack of value). The following equipment shall be integrated into the DDC system:
   a. Variable Frequency Drives

P. Weekly Scheduling: Provide scheduling of DDC terminal units in groups based on occupancy. Work with the Owner to determine how many groups are required and which zones should be included. Individual terminal units shall be able to receive temporary schedules that will override the group schedules. Temporary override buttons at the zone sensor (where specified on point charts) shall override the scheduling to occupied. When groups that consist of more than 20% of terminal units are indexed to occupied, the associated air handling unit shall start if not already running.

Q. Calculated Data Points:
1. Provide calculated data points for actual dirty pressure drop for all variable volume air handling units with supply flow measurement based on the following equation:
   a. Actual Dirty Filter ΔP = (Measured Supply CFM/Design CFM)^2 x Design Dirty Filter ΔP
2. Provide a calculated data point for outside airflow for all fans that have return and outside air mixing dampers and the points required to allow for the following equation:
   a. Outside Airflow = Supply CFM x (MAT-RAT)/(OAT-RAT)
3. Where Supply CFM is measured either on variable volume fans or as balanced on constant volume units, MAT is Mixed Air Temperature, RAT is Return Air Temperature, and OAT is Outside Air Temperature. This point is designed as a check for outside air flow stations accuracy and outside air ventilation minimum damper positions. It should be noted that the accuracy of the calculated outside airflow will diminish as outside air temperature approaches return air temperature. It should be used as a check only when the RAT and OAT are greater than 20° F and the accuracy of the RAT and OAT temperature sensors are assured.

3.02 EXISTING HEATING PLANT WITH HOT WATER BOILERS CONTROL

A. The existing building heating system consists of two gas-fired hot water boilers, two dedicated primary hot water pumps and two secondary hot water pumps. The boilers and hot water loop control are integrated into existing Niagara controller.

3.03 TERMINAL UNIT CONTROL – DDC AND ELECTRIC

A. General: See the valve chart in Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC for requirements for type of valve, signal required, spring return requirements, and fail positions. The valve requirements specified in the Section 23 09 14 valve chart shall supersede what is called out in the terminal unit sequences.

B. DDC Controlled Terminal Unit Master Command Points:

1. Provide individual master software points for each of the following functions that can be executed from a single command through the DDC system:
   a. Command all terminal unit heating valves open (i.e. reheat, radiation, fan coil, etc.).
   b. Command all terminal unit heating valves closed.
   c. Command all terminal unit cooling valves open.
   d. Command all terminal unit cooling valves closed.
   e. Command all VAV terminals to scheduled minimum flow by floor.
   f. Command all VAV terminals to scheduled maximum flow by floor.

3.04 HOT WATER UNIT HEATER CONTROL – DDC CONTROL

A. Each unit heater shall be provided with a DDC controller, a DDC space temperature sensor to control the electric actuated two-way control valve and a strap-on aquastat mounted on the hot water return line to control the unit fan.

B. When the space temperature is below space temperature set point, the hot water control valve shall modulate open as required to maintain the space temperature. When the aquastat senses that hot water returns piping temperature is above 100° F, the unit fan shall cycle on.

1. When the space temperature is above space temperature set point, the hot water control valve shall modulate closed. When the aquastat senses that hot water returns piping temperature is below 100° F, the unit fan shall cycle off.

3.05 HOT WATER UNIT HEATER CONTROL – ELECTRIC CONTROL 2-WAY TCV

A. Each unit heater is provided with an electric space thermostat to control the electric actuated two-way control valve and a strap-on aquastat mounted on the hot water return line to control the unit fan.

B. When the space temperature is below space temperature set point, the hot water control valve shall modulate open as required to maintain the space temperature. When the aquastat senses that hot water returns piping temperature is above 100° F, the unit fan shall cycle on.

1. When the space temperature is above space temperature set point, the hot water control valve shall modulate closed. When the aquastat senses that hot water returns piping temperature is below 100° F, the unit fan shall cycle off.

3.06 HOT WATER UNIT HEATER CONTROL – ELECTRIC CONTROL

A. Each unit heater is provided with an electric space thermostat to control the unit fan.

B. When the space temperature is below space temperature set point the unit fan shall cycle on.

1. When the space temperature is above space temperature set point the unit fan shall cycle off.

3.07 HOT WATER REHEAT COIL CONTROL – DDC CONTROL

A. Each reheat coil shall be provided with a DDC controller and a DDC space temperature sensor to control the electric actuated two-way control valve

B. When the space temperature is below space temperature set point, the hot water control valve shall modulate open as required to maintain the space temperature.

1. When the space temperature is above space temperature set point, the hot water control valve shall modulate closed.
2. The hot water control valve shall be commanded closed whenever the associated air handling unit is off.

3.08 VARIABLE VOLUME AIR TERMINAL UNIT WITH HOT WATER REHEAT

A. Reference sequence of operations on mechanical drawings M500.

3.09 ROOFTOP AIR HANDLING UNIT (RTU-1)

A. Reference sequence of operations on mechanical drawings M500.

END OF SECTION

SECTION 23 21 13
HYDRONIC PIPING

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. Base Bid: Unless noted otherwise, the Mechanical Contractor shall provide all labor and materials for a complete system in this specification.

1.02 SECTION INCLUDES

A. This section contains specifications for all HVAC hydronic pipe and pipe fittings for this project. Included are the following topics:
   1. Heating Hot Water
   2. Vents and Relief Valves
   3. Cooling Coil Condensation Drains
   4. Unions and Flanges
   5. Gaskets
   6. Mechanical Grooved Pipe Connections

1.03 RELATED WORK

A. Applicable provisions of Division 1 govern work under this section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 15 - Piping Specialties
D. Section 23 05 23 - General-Duty Valves for HVAC Piping
E. Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment
F. Section 23 07 00 - HVAC Insulation
G. Section 23 25 00 - HVAC Water Treatment.

1.04 SUBMITTALS

A. Refer to Section 23 05 00 – Common Work Results for HVAC. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Heating Hot Water
   2. Vents and Relief Valves
   3. Cooling Coil Condensation Drains
   4. Unions and Flanges
   5. Gaskets
   6. Mechanical Grooved Pipe Connections
B. Contractor shall submit schedule indicating the ASTM specification number of the pipe being proposed along with its type and grade and sufficient information to indicate the type and rating of fittings for each service.
C. Type F Steel Pipe: Statement from manufacturer on their letterhead that the pipe furnished meets the ASTM specification contained in this section.
D. Type E or S Steel Pipe: Mill certification papers, also known as material test reports, for the pipe furnished for this project, in English. Heat numbers on these papers to match the heat numbers stenciled on the pipe. Chemical analysis indicated on the mill certification papers to meet or exceed the requirements of the referenced ASTM specification.
E. Copper Tube: Statement from manufacturer on their letterhead that the pipe furnished meets the ASTM specification contained in this section.

1.05 REFERENCE STANDARDS

A. ANSI B16.3 Malleable Iron Threaded Fittings
B. ANSI B16.4 Cast Iron Threaded Fittings
C. ANSI B16.5 Pipe Flanges and Flanged Fittings
D. ANSI B16.22 Wrought Copper and Wrought Copper Alloy Solder Joint Pressure Fittings

E. ASTM A53 Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless
F. ASTM A74 Cast Iron Soil Pipe and Fittings
G. ASTM A105 Forgings, Carbon Steel, for Piping Components
H. ASTM A126 Gray Cast Iron Castings for Valves, Flanges, and Pipe Fittings
I. ASTM A181 Forgings, Carbon Steel for General Purpose Piping
J. ASTM A197 Cupola Malleable Iron
K. ASTM A234 Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
L. ASTM A380 Practice for Cleaning and Descaling Stainless Steel Parts, Equipment, and Systems
M. ASTM B75 Seamless Copper Tube
N. ASTM B88 Seamless Copper Water Tube

1.06 QUALITY ASSURANCE

A. Order all Type E and Type S steel pipe with heat numbers rolled, stamped, or stenciled to each length or each bundle, depending on the size of the pipe, and in accordance with the appropriate ASTM specification.
B. Any installed material not meeting the specification requirements must be replaced with material that meets these specifications without additional cost to the Owner.
C. All hydronic piping shall be manufactured in the United States.

1.07 DESIGN CRITERIA

A. Use only new material, free of defects, rust and scale, and meeting the latest revision of ASTM specifications as listed in this specification.
B. Construct all piping for the highest pressures and temperatures in the respective system in accordance with ANSI B31, but not less than 125 psig unless specifically indicated otherwise.
C. Where weld fittings or mechanical grooved fittings are used, use only long radius elbows having a centerline radius of 1.5 pipe diameters.
D. Where ASTM A53 type F pipe is specified, ASTM A53 grade A type E or S, or ASTM A53 grade B type E or S may be substituted at Contractor's option. Where ASTM A53 grade A pipe is specified, ASTM A53 grade B pipe may be substituted at Contractor's option. Where the grade or type is not specified, Contractor may choose from those commercially available.
E. Where ASTM B88, type L hard temper copper tubing is specified, ASTM B88, type K hard temper copper tubing may be substituted at Contractor's option.

1.08 DELIVERY, STORAGE AND HANDLING

A. Promptly inspect shipments to ensure that the material is undamaged and complies with specifications.
B. Cover pipe to eliminate rust and corrosion while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends so they are not damaged. Where end caps are provided or specified, take precautions so the caps remain in place. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.
C. Offsite storage agreements will not relieve the contractor from using proper storage techniques.
D. Storage and protection methods must allow inspection to verify products.

1.09 WELDER QUALIFICATIONS

A. Before any metallic welding is performed, the Contractor shall submit his Standard Welding Procedure Specifications, Procedure Qualification Records and Qualification Test Records for each Welder along with associated continuity records to demonstrate compliance with ASME Section IX, paragraph QW-322.
B. The Contractor shall maintain a complete set of welder qualification documents at the jobsite, including Test Records and Continuity Records for each welder.
C. The A/E or owner reserves the right to test the work of any welder employed on the project, at the Contractor's expense. Testing will include a visual examination of the pipe and weld and may include radiography of any suspect welds. If the work of the welder is found to be unsatisfactory, the welder shall be prevented from doing further welding on the project. Any welds deemed unacceptable will be repaired at the contractor’s expense.

PART 2 – PRODUCTS

2.01 HEATING HOT WATER

A. 2" and Smaller: ASTM A53, type F, standard weight (schedule 40) black steel pipe with ASTM A126/ANSI B16.4, class 125, standard weight cast iron threaded fittings.

B. 2-1/2" and Larger: ASTM A53, standard weight (schedule 40) black steel pipe with ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

C. Contractor may use ASTM B88 seamless, type L, hard temper copper tube with ANSI B16.22 wrought copper solder-joint fittings in lieu of steel pipe for all sizes. Mechanically formed tee fittings may be used in lieu of wrought copper solder-joint tee fittings for branch takeoff up to one-half (1/2) the diameter of the main.

2.02 VENTS AND RELIEF VALVES

A. Use pipe and pipe fittings as specified for the system to which the relief valve or vent is connected.

2.03 COOLING COIL CONDENSATION DRAINS

A. ASTM B88, type L hard temper copper tubing with ASTM B145/ANSI B16.23 cast red bronze or ASTM B75/ANSI B16.29 wrought solder-type drainage fittings.

2.04 UNIONS AND FLANGES

A. 2" and Smaller: ASTM A197/ANSI B16.3 malleable iron unions with brass seats. Use black malleable iron on black steel piping and galvanized malleable iron on galvanized steel piping. Use ANSI B16.18 cast copper alloy unions on copper piping. Use unions of a pressure class equal to or higher than that specified for the fittings of the respective piping service but not less than 250 psi.

B. 2-1/2" and Larger: ASTM A181 or A105, grade 1 hot forged steel flanges of threaded, welding and of a pressure class compatible with that specified for valves, piping specialties and fittings of the respective piping service. Flanges smaller than 2-1/2" may be used as needed for connecting to equipment and piping specialties. Use raised face flanges ANSI B16.5 for mating with other raised face flanges on equipment with flat ring or full-face gaskets. Use ANSI B16.1 flat face flanges with full face gaskets for mating with other flat face flanges on equipment.

C. Dielectric Connections: Union or waterway fitting with water impervious isolation barrier and one galvanized or plated steel end and one copper tube end, end types to match pipe joint types used.

D. Dielectric Unions:
   1. Manufacturers: Capitol Manufacturing Company, Hart Industries, Watts Regulator Company, Zurn Plumbing Products Group, Substitutions: See Section 01 60 00 - Product Requirements.
   2. Unions:
      a. ASME B16.39, Class 250
      b. Body and Nut: Steel with galvanized coating
      c. Insulator: Nylon
      d. Tailpiece: Brass
      e. Gaskets: EPDM
   3. Dielectric unions shall be used when joining pipes of dissimilar metals in piping 2” (50 mm) and under. Connections shall be threaded and/or soldered to conform to materials being joined. Gasket and bushing material for domestic water and chilled water systems shall be rated for fluid temperatures of 180° F (82° C) and under.

E. Dielectric Flanges Kits:
   1. Manufacturers: Advance Products and Systems, Inc., Calpico, Inc., Pipeline Seal and Insulator, Inc., Substitutions: See Section 01 60 0 0- Product Requirements.
   2. Flange:
      a. ASME B16.5, Class 150 or Class 300 weld neck flange to suit service pressure/temperature requirements.
      b. Insulating Sleeves: Phenolic or polyethylene
      c. Washers: Phenolic with steel backing washers
      d. Bolts and Nuts: Flange bolts an nuts shall conform to the requirements of ASME B31.9 – Building Services Piping
      e. Gaskets: Neoprene or phenolic

3. Dielectric flanges shall be used when joining pipes of dissimilar metals in piping 2 ½" (63 mm) and larger. Connections shall be threaded and/or soldered to conform to materials being joined. Gasket and bushing material for domestic water and chilled water systems shall be rated for fluid temperatures of 180° F (82° C) and under.
4. Dielectric couplings may be used in lieu of dielectric unions or flanges in piping ½" through 3" (15 mm through 75 mm). Where dielectric couplings are used, a union shall be placed with 6" (150 mm) of coupling. Dielectric couplings shall not be used where fluid temperature exceeds 200° F (93° C).
5. Dielectric unions, flanges and couplings shall be manufactured and assembled domestically.

2.05 GASKETS

A. Water and Glycol Systems: Branded, compressed, non-asbestos sheet gaskets. Klingersil C4401, Garlock 3000, JM Clipper 978.

2.06 MECHANICAL GROOVED PIPE CONNECTIONS

A. Manufacturers: Victaulic, Grinnell, Central
B. Mechanical grooved pipe couplings and fittings may be used with steel pipe on the systems indicated below. Either cut-groove or equivalent roll-groove products, including gaskets, are acceptable providing the system temperature and pressure requirements are met. Where malleable iron fittings are indicated, they shall conform to ASTM A47. Where forged steel fittings are indicated, they shall conform to ASTM A106, Grade B. Where fabricated steel fittings are indicated, they shall conform to ASTM A53, type F in sizes 3/4" through 1-1/2" and type E or S, grade B in sizes 2" through 20". Do not use fabricated fittings where malleable iron or forged steel fittings are available. Gaskets in all cases shall be EPDM suitable for temperatures to 230 degrees F.
C. The following services may use mechanical grooved pipe connections within the building in mechanical spaces and above accessible ceilings. Mechanical chases are not considered accessible.
   1. Heating Hot Water
   2. Chilled Water
D. Mechanical grooved pipe connections shall not be used in heating plants or below grade utility distribution systems.
E. Mechanical grooved pipe connections shall not be used in chilled water piping between the cooling coil and the isolation valve for that cooling coil.
F. Fittings and couplings must be suitable for the temperature and pressure involved. In no case is the final system to have a pressure rating of less than 125 psig at the design temperature of the fluid.
G. Acceptable fittings and couplings are listed below, based on Victaulic. When used on galvanized piping, fittings and couplings shall be galvanized. When used on black steel piping, fittings and couplings shall have an enamel coating.
H. Couplings: Ductile iron standard couplings, Style 77; lightweight couplings, Style 75; and rigid couplings. Reducing couplings are not acceptable.
I. Flanges: Ductile iron Style 741 or 742 except at lug type butterfly valves where standard welding flanges shall be used.
J. Fittings: Ductile iron elbows and tees of the manufacturer's standard line may be used in all sizes except bullhead tees will not be accepted. Fabricated steel fittings may be used in all sizes where fitting wall thickness conforms to standard weight pipe. Mechanical-T Style 920 fittings with malleable iron housings may be used for up to 2" outlet size.
K. Mechanical grooved pipe couplings are not allowed as a substitute for expansion compensation.
L. Mechanical grooved flexible couplings are not allowed as a substitute for the flexible connectors.

PART 3 – EXECUTION

3.01 ERECTION

A. Carefully inspect all pipe, fittings, valves, equipment and accessories before installation. Any items that are unsuitable, cracked or otherwise defective shall be rejected and removed from the job site immediately. Excluding minor surface rust, piping that exhibits significant oxidation or corrosion will be rejected.

B. 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 item that is not clean.
C. Remove all lose dirt, scale, oil, chips, burrs and other foreign material from the internal and external surfaces of all pipe and piping components prior to assembly, including debris associated with cutting, threading and welding.
D. During fabrication and assembly, remove slag and weld spatter from internal pipe surfaces at all joints by peening, chipping and wire brushing.
E. During construction, until system is fully operational, keep all openings in piping and equipment closed except when actual work is being performed on that item of the system. Use plugs, caps, blind flanges or other items designed for this purpose.
F. Furnish and install all flanges, caps, bypasses, drains, valves, etc. required to facilitate flushing and draining all system piping.
G. Install all piping parallel to building walls and ceilings and at heights which do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. In all cases, consult all project drawings for location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.
H. Provide anchors, expansion joints, swing joints and/or expansion loops so that piping may expand and contract without damage to itself, equipment, or building.
I. Mitered ells, notched tees, and orange peel reducers are not acceptable. On threaded piping, bushings are not acceptable.
J. "Weldolets" and "Threadolets" may be used for branch takeoffs up to one-half (1/2) the diameter of the main.
K. Install drains throughout the systems to permit complete drainage.
L. Unless written authorization by the A/E, do not route piping through transformer vaults or above transformers, panelboards, motor control centers or switchboards, including the required service space for this equipment, unless the piping is serving this equipment
M. Install all valves, control valves, and piping specialties, including items furnished by others, as specified and/or detailed. Make connections to all equipment installed by others where that equipment requires the piping services indicated in the specifications and drawings.

3.02 WELDED PIPE JOINTS

A. Make all welded joints by fusion welding in accordance with ASME Codes, ANSI B31, and State Codes where applicable.
B. All pipe welding shall be completed by Qualified Welders in accordance with the Contractor's Procedure Specifications.
C. Contractor will ensure that these steps are followed where pipe sections will be joined by welding:
    1. Cleaning – Welding surfaces will be clean and free of defects.
    2. Alignment – Inside diameter of piping components will be aligned as accurately as possible. Internal misalignment shall not exceed 1/16".
    3. Spacing – Pipe sections will be spaced to allow deposition of weld filler material through the entire weld joint thickness.
D. Girth Butt Welds:
    1. Girth butt welds shall be complete penetration welds.
    2. Concavity will not exceed 1/32"
    3. Under cuts will not exceed 1/32"
    4. As welded surfaces are permitted however surfaces will be free from coarse ripples, grooves, abrupt ridges and valleys.
E. Electrodes shall be manufactured in the U.S.A. with coating and diameter as recommended by the manufacturer for the type and thickness of work being done.

3.03 THREADED PIPE JOINTS

A. Use a Teflon based thread lubricant or Teflon tape when making joints; no hard setting pipe thread cement or caulking will be allowed.

3.04 MECHANICAL GROOVED PIPE CONNECTIONS

A. Use pipe factory grooved in accordance with the coupling manufacturer's specifications or field grooved pipe in accordance with the same specifications using specially designed tools available for the application.

B. Lubricate pipe and coupling gasket, align pipe, and secure joint in accordance with the coupling manufacturer's specifications.

C. Support pipe as indicated in the specifications except as modified below. Support each horizontal pipe section at least once between couplings and whenever a change in direction of line flow takes place. Support vertical pipe at every other floor or every other pipe length, whichever is most frequent. Set the base of the riser or the base fitting on a pedestal or foundation.

D. Follow coupling manufacturer's installation recommendations if they are more stringent that the above requirements.

3.05 COPPER PIPE JOINTS

A. Remove all slivers and burrs remaining from the cutting operation by reaming and filing both pipe surfaces. Clean fitting and tube with emery cloth or sandpaper. Remove residue from the cleaning operation, apply flux, and assemble joint. Use 95-5 solder or silver brazing alloy to secure joint as specified for the specific piping service.

B. Where mechanically formed tee fittings are allowed, form mechanically extracted collars in a continuous operation, consisting of drilling a pilot hole and drawing out the tube surface to form a collar having a height of not less than three times the thickness of the tube wall. Use an adjustable collaring device. Notch and dimple the branch tube. Braze the joint, applying heat properly so that pipe and tee do not distort; remove distorted connections.

3.06 WATER SYSTEM

A. Run water mains level or pitch horizontal mains up 1 inch in 40 feet in the direction of flow. Install manual air vents at all high points where air may collect. If vent is not in an accessible location, extend air vent piping to the nearest code acceptable drain location with vent valve located at the drain.

B. Main branches and runouts to terminal equipment may be made at the top, top 45-degree, side, and/or bottom 45 degree of the main provided that there are drain valves suitably located for complete system drainage and manual air vents are located at all top and top 45-degree connections. Bottom connections are not acceptable unless approved by the Owner.

C. Use top or top 45-degree connection to main for up feed risers and bottom 45-degree connection to main for down feed risers. Bottom connections are not acceptable unless approved by the Owner.

D. Use a minimum of two elbows in each pipe line to a piece of terminal equipment to provide flexibility for expansion and contraction of the piping systems. Offset pipe connections at equipment to allow for service, such as removal of the terminal device.

E. Use eccentric fittings for changes in horizontal pipe sizes with the fittings installed for proper air venting. Concentric fittings may be used for changes in vertical pipe sizes.

3.07 MAKEUP WATER

A. Install where indicated and/or specified, including all valves, piping specialties and dielectric unions required for a functional system.

3.08 CHEMICAL TREATMENT

A. Install chemical treatment piping as indicated on the drawings, as detailed, and as recommended by the supplier of the chemical treatment equipment, IWM – Industrial Water Management.

3.09 VENTS AND RELIEF VALVES

A. Install vent and relief valve discharge lines as indicated on the drawings, as detailed, and as specified for each specific valve or piping specialty item. In no event is a termination to occur less than six feet above a roof line.

3.10 COOLING COIL CONDENSATION DRAINS

A. Trap each cooling coil drain pan connection with a trap seal of sufficient depth to prevent conditioned air from moving through the piping. Extend drain piping to nearest code approved drain location. Construct trap with plugged tee for cleanout purposes as detailed.

3.11 UNIONS AND FLANGES

A. Install a union or flange, as required, at each automatic control valve and at each piping specialty or piece of equipment which may require removal for maintenance, repair, or replacement. Where a valve is located at a piece of equipment, locate the flange or union connection on the equipment side of the valve. Concealed unions or flanges are not acceptable.

B. Dielectric Connections:
   1. Comply with manufacturer's recommendations.
   2. Install in following locations:
      a. Pipe joints connecting dissimilar metals
      b. Pipe joints connecting similar metals where required for cathodically protecting pipe lines from adjoining pipe sections.
   3. Joints and gasketing materials rated to withstand temperature, pressure and other characteristics of services for which used including testing pressure.
   4. Make screwed joints with insulating unions.
   5. Make flanged joints with insulating jackets, bolt sleeves and washers.
   6. Bronze valve between dissimilar metals without the above insulating dielectric connections shall not be considered a dielectric connection.

3.12 GASKETS

A. Store horizontally in cool, dry location and protect from sunlight, water and chemicals. Inspect flange surfaces for warping, radial scoring or heavy tool marks. Inspect fasteners, nuts and washers for burrs or cracks. Replace defective materials.

B. Align flanges parallel and perpendicular with bolt holes centered without using excessive force. Center gasket in opening. Lubricate fastener threads, nuts and washers with lubricant formulated for application.

C. Draw flanges together evenly to avoid pinching gasket. Tighten fasteners in cross pattern sequence (12 – 6 o'clock, 3 – 9 o'clock, etc.), one pass by hand and four passes by torque wrench at 30% full torque, 60% full torque and two passes at full torque per ASME B16.5.

3.13 PIPING SYSTEM LEAK TESTS

A. Verify that the piping system being tested is fully connected to all components and that all equipment is properly installed, wired, and ready for operation. If required for the additional pressure load under test, provide temporary restraints at expansion joints or isolate them during the test. Verify that hangers can withstand any additional weight load that may be imposed by the test.

B. Provide all piping, fittings, blind flanges, and equipment to perform the testing.

C. Conduct pressure test with test medium of air or water unless specifically indicated. Minimum test time is indicated in the table below; additional time may be necessary to conduct an examination for leakage. Each test must be witnessed by the Owner's representative. If leaks are found, repair the area with new materials and repeat the test; caulking will not be acceptable.

D. Do not insulate pipe fittings or welds until test has been successfully completed.

E. For hydrostatic tests, use clean water and remove all air from the piping being tested by means of air vents or loosening of flanges/unions. Measure and record test pressure at the high point in the system.

F. For air tests, gradually increase the pressure to not more than one half of the test pressure; then increase the pressure in steps of approximately one-tenth of the test pressure until the required test pressure is reached. Examine all joints and connections with a soap bubble solution or equivalent method. The piping system exclusive of possible localized instances at pump or valve packing shall show no evidence of leaking. After testing is complete, slowly release the pressure in a safe manner.

System	Pressure	Medium	Duration
Heating hot water	100 psig	Water	8 hr.
Chilled water	100 psig	Water	8 hr.
Condenser water	100 psig	Water	8 hr.
Reclaim water	100 psig	Water	8 hr.

G. All pressure tests are to be documented on attached form included in this specification.
H. On piping that cannot be tested because of connection to an active line, provide temporary blind flanges and hydrostatically test new section of piping. After completion of test, remove temporary flanges and make final connections to piping. Die penetrate test pass weld or x-ray the piping that was not hydrostatically tested up to the active system.

3.14 HYDRONIC PIPING SYSTEM FLUSHING

A. All new chilled water and heating hot water system piping shall be flushed thoroughly before the systems are put in to operation. Subsequent to executing the chemical cleaning processes specified in Section 23 25 00 – HVAC WATER TREATMENT, and prior to adding scale and corrosion inhibitors, flush all piping and components with a clean source of water until the discharge from the system is clean. Discharge shall be from drains provided at all low points in the piping, ends of headers and as otherwise necessary to flush and drain the entire system.
B. Project specific procedures shall be established prior to flushing. Before beginning flushing operations, submit proposed flushing procedures to the A/E and Owner's Project Representative for review and approval. Provide sufficient notice to the A/E and/or Owner to allow the flushing operations to be observed.
C. A clean water source shall be tapped into the system downstream of the main circulation pump(s). Provide minimum 2" connection between water source and hot water/chilled water systems including taps with ball valves (or line size tap and ball valve for piping systems smaller than 2"). Provide minimum 2" taps (or line size if mains are smaller than 2") at the ends of headers, the low pint of each of the mains on each floor and as otherwise necessary to flush and drain the entire system. Provide minimum 2" bypass with shut off valve (or line size if mains are smaller than 2") between the supply and return mains on each floor as where directed by the A/E and Owner's Project Representative or where shown on the drawings. Contractor shall identify proposed clean water source along with the method/location of drain discharge and review with the A/E and Owner's Project Representative prior to installing flushing connections to water source and drain outlets. Provide code required temporary backflow prevention for the clean water source if needed. Provide all temporary taps, valves, piping, bypasses and hoses as needed to accomplish flushing procedures.
D. The Owner's district chilled water system shall NOT be used as a source of water for flushing any piping.
E. Flush piping systems using the following procedure:
    1. Flushing sequence for hot water and chilled water systems is as follows:
    2. Close isolation valves at all coils and wall fin.
    3. Open the temporary bypasses that connect the ends of supply and return mains.
    4. Flush mains by turning on flushing water source and sequentially opening drains on mains on each floor until the discharge is clean. This will flush the mains without forcing water/debris into the branches and run out pipes.
    5. Close isolation valves located downstream of coils/wall fin.
    6. Open isolation valves located upstream of coils/wall fin.
    7. Open individual drain valves upstream of coils/wall fin until the discharge is clean. This will flush the supply branch and run out lines between the mains and the coils/wall fin without running water/debris through the TCV or coils/wall fin.
    8. Close the individual drain valves upstream of coils/wall fin.
    9. Open drain valves at low points in the return piping mains.
    10. Open the individual isolation valves located downstream of the coils/wall fin. This will flush the return branch and run out lines located between the coils/wall fin and the mains back into the mains and out the drains on the return mains. The water going through the coil/wall fin should be already be clean since this section was flushed previously.
    11. Repeat steps 1-3 to clean debris from the mains.
F. Isolate all coils while flushing risers and mains. Flush the mains on each floor individually, starting at the top of the building and working down towards the basement level. After risers and mains have been flushed clean, individually open the drain valves in each branch circuit to discharge any debris that may have accumulated in the branch piping.

G. As directed by Owner, the Contractor will be required to open drain valves at selected locations in the system to verify the effectiveness of flushing procedures. If sediment or debris is identified in the system, it will be flushed again and re-inspected at no expense to the Owner.
H. After flushing operations are complete, drain and/or blow out any residual water, clean and replace all strainers, and add scale and corrosion inhibitors as specified in Section 23 25 00. Leave flushing connections/valves in place and cap.
I. All flushing procedures shall be documented by completing and submitting the report form included at the end of this Section.
J. Initial Fill and Vent:
    1. Fill hydronic systems with appropriate working fluids as specified. All system fluids shall be chemically treated as specified in Section 23 25 00 – HVAC WATER TREATMENT.
    2. For closed piping systems, all air trapped at high points shall be relieved through the manual air vents prior to notifying Owner that the systems are ready to be tested and balanced.

END OF SECTION

PIPING SYSTEM LEAKAGE TEST REPORT

Date Submitted: _____

Project Name: _____

Location: _____ **Project No:** _____

Contractor: _____

Test Medium:
□ **HVAC** □ **Refrigeration** □ **Controls**
□ **Power Plant** □ **Plumbing** □ **Sprinkler**
□ **Air** □ **Water** □ **Other** _____

Test performed per specification section No. _____

Specified Test Duration _____ Hours **Specified Test Pressure** _____ **PSIG**

System Identification: _____

Describe Location: _____

_____

Test Date: _____

Start Test Time: _____ **Initial Pressure:** _____ **PSIG**

Stop Test Time: _____ **Final Pressure:** _____ **PSIG**

Tested By: _____ **Witnessed By:** _____

Title: _____ **Title:** _____

Signed: _____ **Signed:** _____

Date: _____ **Date:** _____

Comments: _____

_____

_____

_____

_____

_____

_____

PIPING SYSTEM FLUSHING REPORT

Date Submitted: _____

Project Name: _____

Location: _____ **Project No:** _____

Contractor: _____

System Identification (check one):

□ **Chilled Water** □ **Process Chilled Water** □ **Heat Reclaim**

□ **Heating Hot Water** □ **Other** _____

Describe procedure: _____

_____

_____

_____

_____

Flush Date: _____ **Start Time:** _____ **Stop Time:** _____

Pressure of Water Source: _____ **PSIG** **Describe water source and method of connection to source:**

_____

_____

_____

Flushed By: _____ **Witnessed By:** _____

Title: _____ **Title:** _____

Company: _____ **Agency:** _____

Signed: _____ **Signed:** _____

Date: _____ **Date:** _____

Describe results: _____

_____

_____

_____

SECTION 23 31 00
HVAC DUCTS AND CASINGS

PART 1 **– GENERAL**

1.01 **SCOPE OF WORK**

A. Base Bid: Unless noted otherwise, the Ventilating Contractor shall provide all labor and materials for a complete system in this specification section.

1.02 **SECTION INCLUDES**

A. This section includes specifications for all duct systems used on this project. Included are the following topics:
   1. Low Pressure Ductwork (Maximum 2-inch pressure class)
   2. Duct Sealant
   3. Gaskets

1.03 **RELATED WORK**

A. Applicable provisions of Division 1 govern work under this Section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC
D. Section 23 33 00 – Air Duct Accessories

1.04 **SUBMITTALS**

A. Refer to Section 23 05 00 – Common Work Results for HVAC, Submittals. In addition to the general content specified under Section 20 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Low Pressure Ductwork (Maximum 2-inch pressure class)
   2. Duct Sealant
   3. Gaskets
B. Include manufacturer's data and/or Contractor data for the following:
C. Fabrication and installation drawings.
   1. Schedule of duct systems including material of construction, gauge, pressure class, system class, method of reinforcement, joint construction, fitting construction, and support methods, all with details as appropriate.
   2. Duct sealant and gasket material.

1.05 **REFERENCE STANDARDS**

A.	ANSI SS-EN 485-2	Aluminum and Aluminum Alloys-Sheet, Strip and Plate-Part 2: Mechanical Properties
B.	ASTM B209	Specification for Aluminum and Aluminum-Alloy Sheet and Plate
C.	ASTM A90	Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
D.	ASTM A167	Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
E.	ASTM A623	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
F.	ASTM A527	Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
G.	ASTM 924	Standard Specification for General Requirements for Sheet Steel, Metallic-coated by the Hot-dip Method
H.	ASTM E 84	Test Method for Surface Burning Characteristics of Building Materials
I.	ASTM C 1338	Test Method for Determining Fungal Resistance of Insulation Materials and Facings
J.	ASTM G 21	Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

K. ASTM C 916 Standard Specification for Adhesives for Duct Thermal Insulation NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems
L. UL 181 Standard for Safety for Factory Made Air Ducts and Air Connectors.

1.06 **QUALITY ASSURANCE**
A. Refer to division 1 for equals and substitutions.

1.07 **DESIGN CRITERIA**
A. Construct all ductwork to be free from vibration, chatter, objectionable pulsations and leakage under specified operating conditions.
B. Use material, weight, thickness, gauge, construction and installation methods as outlined in the following SMACNA publications, unless noted otherwise:
1. HVAC Duct Construction Standards, Metal and Flexible, 3rd Edition, 2005
2. HVAC Air Duct Leakage Test Manual, 1st Edition, 1985
3. HVAC Systems - Duct Design, 4th Edition, 2006
4. Rectangular Industrial Duct Construction Standard, 2nd Edition, 2004
5. Round Industrial Duct Construction Standards, 2nd Edition, 1999
6. Thermoplastic Duct (PVC) Construction Manual, 2nd Edition, 1995
C. Use products which conform to NFPA 90A, possessing a flame spread rating of not over 25 and a smoke developed rating no higher than 50.

1.08 **DELIVERY, STORAGE AND HANDLING**
A. Promptly inspect shipments to ensure that Ductwork is undamaged and complies with the specification.
B. Protect Ductwork against damage.
C. Protect Ductwork by storing inside or by durable, waterproof, above ground packaging. Do not store material on grade. Protect Ductwork from dirt, dust, construction debris and foreign material. Where end caps/packaging are provided, take precautions so caps/packaging remain in place and free from damage.
D. Offsite storage agreements do not relieve the contractor from using proper storage techniques.
E. Storage and protection methods must allow inspection to verify products.

PART 2 **– PRODUCTS**

2.01 **GENERAL**
A. All sheet metal used for construction of duct shall be 24 gauge or heavier except for round and spiral ductwork and spiral duct take-offs 12” and below may be 26 gauge where allowed in SMACNA HVAC Duct Construction Standards, Metal and Flexible, 3rd Edition, 2005.
B. Duct sizes indicated on plans are net inside dimensions; where duct liner is specified, dimensions are net, inside of liner.

2.02 **DUCTWORK PRESSURE CLASS**
A. Minimum acceptable SMACNA duct pressure class, for all ductwork except transfer ductwork, is 2 inch W.G. positive or negative, depending on the application. Transfer ductwork minimum acceptable duct pressure class is 1 inch W.G. positive or negative, depending on the application. Duct system pressure classes not indicated on the drawings to be as follows:

Supply duct upstream of VAV boxes	2 in. pressure class
Supply duct downstream of VAV terminals	2 in. pressure class
Transfer ducts	1 in. pressure class
Relief ducts	3 in. pressure class

2.03 **MATERIALS**
A. Galvanized Steel Sheet: Use ASTM A 653 galvanized steel sheet of lock forming quality. Galvanized coating to be 1.25 ounces per square foot, both sides of sheet, G90 in accordance with ASTM A90. Provide “Paint Grip” finish or galvanneal sheet metal for ductwork that will be painted.

B. Uncoated Black Steel Sheet: First quality, soft steel sheet capable of welding or double seaming without fracture.
C. Aluminum Sheet: Use ANSI/ASTM B209 aluminum sheet, alloy 3003H-14, capable of double seaming without fracture.
D. Stainless Steel Sheet: Use ASTM A167, Type 304 or 316 stainless steel sheet as specified, 316L if welded ductwork, with No. 2B finish for concealed work and No. 3 finish for exposed work.
E. Polyvinylchloride Coated Steel Sheet:
   1. Use hot-dipped galvanized steel sheet with prime coat and a polyvinyl chloride film on both sides. Thickness of coating to be a minimum of 4 mils on each side. United Sheet Metal Uni-Coat, made by United McGill Co., may be used at contractor's option.
   2. Where any duct surface is scratched, marred, or otherwise damaged, paint with PVC aerosol spray.
   3. All couplings shall be slip-joint construction with a minimum 2 inches insertion length. Seal all couplings with sealants as specified.
F. Prefabricated Grease Ducts: Dual wall construction with stainless steel inner liner, insulation and stainless steel (for exposed locations) or aluminized steel (for concealed locations) shell. Furnish all items which form a part of the assembly, including, tee sections, straight sections, elbows, end caps, cleanouts, expansion joints, fan/hood transitions, supports, flashing, counter flashing, and insulated roof thimble where required. Each section shall bear the factory applied Underwriters Laboratories Label.

2.04 **LOW PRESSURE DUCTWORK (MAXIMUM 2 INCH PRESSURE CLASS)**

A. Fabricate and install ductwork in sizes indicated on the drawings and in accordance with SMACNA recommendations, except as modified below.
B. Construct so that all interior surfaces are smooth. Use slip and drive or flanged and bolted construction when fabricating rectangular ductwork. Use spiral lock seam construction when fabricating round spiral ductwork. Sheet metal screws may be used on duct hangers, transverse joints and other SMACNA approved locations if the screw does not extend more than 1/2 inch into the duct.
C. Use elbows and tees with a center line radius to width or diameter ratio of 1.5 wherever space permits. When a shorter radius must be used due to limited space, install single wall sheet metal splitter vanes in accordance with SMACNA publications, Type RE 3. Where space will not allow and the C value of the radius elbow, as given in SMACNA publications, exceeds 0.31, use rectangular elbows with turning vanes as specified in Section 23 33 00 – Air Duct Accessories. Square throat-radius heel elbows will not be acceptable. Straight taps or bullhead tees are not acceptable.
D. Where rectangular elbows are used, provide turning vanes in accordance with Section 23 33 00 – Air Duct Accessories.
E. Provide expanded take-offs or 45 degree entry fittings for branch duct connections with branch ductwork airflow velocities greater than 700 fpm. Square edge 90-degree take-off fittings or straight taps will not be accepted.
F. Button punch snap lock construction will not be accepted on aluminum ductwork.
G. No variation of duct configuration or sizes permitted except by written permission of the Architect/Engineer. Substitution of round ducts for rectangular ducts will only be considered if sized in accordance with ASHRAE table of equivalent rectangular and round ducts.
H. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.
I. Transverse joints for rectangular ducts shall be in accordance with SMACNA HVAC Duct Construction Standards type T-15 through T-24.
J. Button punch snap lock (SMACNA L-2) and grooved seams (SMACNA L-3) shall not be used on rectangular duct longitudinal seams.
K. Longitudinal seams for round ducts shall be lock type spiral seam (SMACNA RL-1) or grooved seam (SMACNA RL-5).
L. Snap lock seams are acceptable on low pressure round ducts with a diameter of 12” or less.

2.05 **DUCT SEALANT**

A. Manufacturer: 3M 800, 3M 900, H.B. Fuller/Foster, Hard cast, Hardcast Peal & Seal, Lockformer cold sealant, Mon-Eco Industries, United Sheet Metal. Silicone sealants are not allowed in any type of ductwork installation.
B. Install sealants in strict accordance with manufacturer's recommendations, paying special attention to temperature limitations. Allow sealant to fully cure before pressure testing of ductwork, or before startup of air handling systems.
C. For plenums installations, use duct sealant with a flame spread index of not more than 25 and smoke-developed index of not more than 50. When tested in accordance with ASTME84 or UL 723.

2.06 **GASKETS**

A. 2 Inch Pressure Class And Lower: Soft neoprene or butyl gaskets in combination with duct sealant for flanged joints.
B. 3 Inch Pressure Class And Higher: Butyl gaskets.
C. Fume Hood Exhaust: Butyl gaskets.

PART 3 **– EXECUTION**

3.01 **INSTALLATION**

A. Verify dimensions at the site, making field measurements and drawings necessary for fabrication and erection. Check plans showing work of other trades and consult with Architect in the event of any interference.
B. Make allowances for beams, pipes or other obstructions in building construction and for work of other contractors. Transform, divide or offset ducts as required, in accordance with SMACNA HVAC Duct Construction Standards, Figure 4-7, except do not reduce duct to less than six inches in any dimension and do not exceed an 8:1 aspect ratio. Where it is necessary to take pipes or similar obstructions through ducts, construct easement as indicated in SMACNA HVAC Duct Construction Standards, Figure 4-8, Fig. E. In all cases, seal to prevent air leakage. Pipes or similar obstructions may not pass through high pressure ductwork, fume exhaust ductwork or kitchen hood exhaust ductwork.
C. Test openings for test and balance work will be provided under Section 23 05 93 – Testing, Adjusting and Balancing for HVAC.
D. Provide frames constructed of angles or channels for coils, filters, dampers or other devices installed in duct systems, and make all connections to such equipment including equipment furnished by others. Secure frames with gaskets and screws or nut, bolts and washers.
E. Install duct to pitch toward outside air intakes and drain to outside of building. Solder or seal seams to form watertight joints.
F. Where two different metal ducts meet, the joint shall be installed in such a manner that metal ducts do not contact each other by using proper seal or compound.
G. Install all motor operated dampers and connect to or install all equipment furnished by others. Blank off all unused portions of louvers, as indicated on the drawings, with 1-1/2 inch board insulation with galvanized sheet metal backing on both sides.
H. Do not install ductwork through dedicated electrical rooms or spaces unless the ductwork is serving this room or space.
I. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
J. Provide adequate access to ductwork for cleaning purposes.
K. Provide temporary capping of ductwork openings on job site, both before and after installation, to prevent entry of dirt, dust and foreign material.
L. Protect diffusers, registers and grilles with plastic wrap or some other approved form of protection to maintain dirt and dust free and to prevent entry of dirt, dust and foreign material into the ductwork.
M. Install prefabricated grease ductwork assemblies in accordance with manufacturer requirements and NFPA 96.
N. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
O. All ductwork not welded, at a minimum, shall be sealed using duct sealant or gaskets on all seams, joints and penetrations.

P. Provide 45 degree entry fitting with a minimum throat length of 25% of the width of the branch duct takeoff or 4 inches, whichever is larger.

3.02 **DUCTWORK SUPPORT**

A. Support ductwork in accordance with the latest SMACNA HVAC Duct Construction Standards, Figure 5-5, except supporting ductwork with secure wire method is not allowed.
B. Support with 3/32 inch, 7 x 7, stainless steel air-craft cable, with matching fastener rated for 50% of actual load, will be allowed on round ductwork under 12 inches if installed as detailed, with cable double looped on duct and at point of support.
C. On ductwork sections exceeding 8', provide at least two supports.

3.03 **LOW PRESSURE DUCT (MAXIMUM 2 INCH PRESSURE CLASS)**

A. Seal all duct, with the exception of transfer ducts, in accordance with SMACNA seal class "A". All seams, joints, and penetrations shall be sealed using duct sealant or gaskets per Part 2 - Products.
B. Install a manual balancing damper in each branch duct and for each diffuser or grille. The use of splitter dampers, extractors, or grille face dampers will not be accepted for balancing dampers.
C. Hangers must be wrapped around bottom edge of duct and securely fastened to duct with sheet metal screws or pop rivets. Trapeze hangers may be used at contractor's option.

3.04 **LEAKAGE TEST**

A. Test all ductwork in accordance with test methods described in Section 5 of SMACNA HVAC Air Duct Leakage Test Manual. Do not insulate ductwork until it has been successfully tested. Test pressure shall be equal to the duct pressure class.
B. If excessive air leakage is found locate leaks, repair the duct in the area of the leak, seal the duct, and retest.
C. Leakage rate shall not exceed more than 5% of the system air quantity for low pressure ductwork, determined in accordance with Appendix C of the SMACNA HVAC Air Duct Leakage Test Manual.
D. Leakage rate shall not exceed more that 1% of the system air quantity for high pressure ductwork, determined in accordance with Appendix C of the SMACNA HVAC Air Duct Leakage Test Manual.
E. Leakage test for ductwork downstream of air terminal devices may be omitted but will not relieve the contractor from duct sealing requirements.
F. Submit a signed report to the Owner, indicating test apparatus used, results of the leakage test, and any remedial work required to bring duct systems into compliance with specified leakage rates.

3.05 **STRUCTURAL TEST**

A. Random test all ductwork per owner's direction. Do not insulate ductwork until it has been successfully tested.
B. Deflection limits shall not exceed those listed in accordance with Chapter 11 of SMACNA HVAC Duct Construction Standards, 3.0 Performance Requirements.
C. Submit a signed report to the Owner, indicating test apparatus used, results of the structural test, and any remedial work required.

END OF SECTION

DUCT LEAKAGE TEST REPORT

Project Number: _____

Date Submitted: _____

Project Name: _____

Location: _____

Contractor: _____

System: **Fan No.:** _____ **Leakage Class (C_L):** _____

Data **Fan Design CFM:** _____ **Duct Pressure Class (P_c):** _____

Test Pressure (P_T): _____

Test Equipment: **Manufacturer:** _____

Model No.: _____ **Serial No.:** _____

For large systems, use the reverse side for a simple sketch of the entire duct system. Then use letter designations to indicate the various duct sections being tested at one time. Also use the reverse side for test comments.

Note that due to normal construction sequencing it is usually necessary to test risers separately prior to enclosing chases.

Design Data									Field Test Data			
			Allowable Leakage		Diameter		Pressure (in. wc.)					
Duct Section	Duct Shape	Duct Surface (Ft2)	Leakage Factor ($P^{.65}C_L$)	CFM for Section	Tube (D_1)	Orifice (D_2)	In Duct (P)	Across Orifice (P_{drop})	Date	Performed By	Observed By	Actual CFM
TOTAL												

DUCT STRUCTURAL TEST REPORT

Project Number: _____

Date Submitted: _____

Project Name: _____

Location: _____

Contractor: _____

System: **Fan No.:** _____

Description of Test Method: _____

_____

_____

Test Equipment: **Manufacturer:** _____

Model No.: _____ **Serial No.:** _____

For large systems, use the reverse side for a simple sketch of the entire duct system. Then use letter designations to indicate the various duct sections being tested at one time. Also use the reverse side for test comments.

Note that due to normal construction sequencing it is usually necessary to test risers separately prior to enclosing chases.

Design Data									Field Test Data					
Duct Test Location	Ductwork Shape		Duct Pressure Class	Allowable Ductwork Wall Deflection		Allowable Joint/ Reinforcement Deflection		Pressure (in. wc.) In Duct	Measured Ductwork Wall Deflection		Measured Joint/ Reinforcement Deflection		Perfor-med By/Date	Witnes-sed By/Date
	H	W		H	W	H	W		H	W	H	W		

SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. Base Bid: Unless noted otherwise, the Mechanical Contractor shall provide all labor and materials for a complete system in this specification section.

1.02 SECTION INCLUDES

A. This section includes accessories used in the installation of duct systems. Included are the following topics:
   1. Manual Volume Dampers
   2. Turning Vanes
   3. Fire Dampers
   4. Control Dampers
   5. Smoke Detectors
   6. Access Doors
   7. Flexible Duct
   8. Flashings
   9. Duct Flexible Connections

1.03 RELATED WORK

A. Applicable provisions of Division 1 govern work under this Section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 29 – Hanger and Supports for HVAC Piping and Equipment
D. Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment
E. Section 23 09 93 – Sequence of Operations for HVAC Controls
F. Section 23 31 00 – HVAC Ducts and Casings

1.04 SUBMITTALS

A. Refer to Section 23 05 00 – Common Work Results for HVAC, Submittals. In addition to the general content specified under Section 20 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Manual Volume Dampers
   2. Turning Vanes
   3. Fire Dampers
   4. Control Dampers
   5. Smoke Detectors
   6. Access Doors
   7. Duct Pressure Relief Doors
   8. Flexible Duct
   9. Duct Flexible Connections
B. Submit for all accessories and include dimensions, capacities, ratings, installation instructions, and appropriate identification.
C. Include certified test data on dynamic insertion loss, self-noise power levels, and aerodynamic performance of sound attenuators.
D. Submit manufacturer's color charts where finish color is specified to be selected by the Architect/Engineer.

1.05 REFERENCE STANDARDS

A. NAIMA Fibrous Glass Duct Liner Standard
B. NFPA 90A Standard for Installation of Air Conditioning and Ventilating Systems
C. SMACNA HVAC Duct Construction Standards - Metal and Flexible, 2nd Edition, 1995
D. UL 214

E. UL 555 (6th edition) Standard for Fire Dampers and Ceiling Dampers
F. UL 555S (4th edition) Leakage Rated Dampers for Use in Smoke Control Systems

1.06 QUALITY ASSURANCE

A. Refer to Division 1 for equals and substitutions

1.07 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 - Common Work Results for HVAC.

PART 2 – PRODUCTS

2.01 MANUAL VOLUME DAMPERS

A. Manufacturers: Ruskin, Vent Products, Air Balance.
B. Dampers must be constructed in accordance with SMACNA Fig. 2-12, Fig. 2-13, and notes relating to these figures, except as modified below.
C. Reinforce all blades to prevent vibration, flutter, or other noise. Construct dampers in multiple sections with mullions where width is over 48 inches. Use rivets or tack welds to secure individual components; sheet metal screws will not be accepted. Provide operators with locking devices and damper position indicators for each damper; use an elevated platform on insulated ducts. Provide end bearings or bushings for all volume damper rods penetrating ductwork constructed to a 3" w.c. pressure class or above.

2.02 TURNING VANES

A. Manufacturers: Aero Dyne, Anemostat, Barber-Colman, Hart & Cooley.
B. Construct turning vanes and runners for square elbows in accordance with SMACNA Fig. 2-3 and Fig. 2-4 except use only airfoil type vanes. Construct turning vanes for short radius elbows and elbows where one-dimension changes in the turn in accordance with SMACNA Fig. 2-5 and Fig. 2-6.

2.03 FIRE DAMPERS

A. Manufacturers: Air Balance, Advanced Air, American Warming and Ventilating, Greenheck, Phillips-Aire, Prefco, Ruskin, Safe-Air.
B. All type B curtain type fire damper blades shall not inhibit the free area of connecting ductwork. Unless high temperature fire dampers are required, select fusible links for 160° F release.
C. Static Fire Dampers: Do not provide static fire dampers.
D. Dynamic Fire Dampers:
   1. All fire dampers shall be dynamic.
   2. Dynamic fire damper assemblies must be UL 555 (6th edition) listed and labeled for dynamic applications (where air systems operate during a fire) and meet requirements of NFPA 90A. Dampers in ducts with a wall mounted grille on one side of the wall shall be type A. Dampers in round or oval ducts shall be type C. Dampers larger than 30” by 30” or with velocity rating requirements of 3000 fpm or higher, may be multiblade type with blades located in the airstream. All other dampers shall be type B curtain dampers. Velocity ratings and static pressure ratings as indicated on the drawings. Damper fire rating to be compatible with the rating of the building assembly in which the damper is used.

2.04 CONTROL DAMPERS

A. Control dampers are specified in section 23 09 14.

2.05 SMOKE DETECTORS

A. Each duct smoke detector indicated on the contract documents shall be installed in cooperation with the electrical contractors. Duct detector locations shown are diagrammatic only and require pressure differential testing to insure proper smoke detector operation. Each duct detector housing and sampling tube kit installed shall be mounted and tested prior to the installation of the duct smoke detector. Air sampling tube installation shall be tested per the manufacturer’s written instructions.

B. The Electrical contractor shall furnish the duct detector assembly and sampling tube kits sized for the installation locations indicated on the mechanical ductwork drawings. This contractor shall maintain possession of the duct detector smoke detection device.
C. The Electrical contractor shall provide smoke detector installation, interconnecting cabling, and testing of the smoke detection system in accordance with the specification.
D. Mechanical Contractor shall install detector housing and sampling tubes in accordance with the listing manufacturer's installation instructions, project documentation, and provide differential pressure testing and adjustments as described in Section 3 – Execution.

2.06 ACCESS DOORS

A. Access door to be designed and constructed for the pressure class of the duct in which the door is to be installed. Doors in exposed areas shall be hinged type with cam sash lock. Hinges shall be steel full length continuous piano type. Doors in concealed spaces may be secured in place with cam sash latches. For both hinged and non-hinged doors provide sufficient number of camp sash latches to provide air tight seal when door is closed. Do not use hinged doors in concealed spaces if this will restrict access. Use minimum 1" deep 24-gauge galvanized steel double wall access doors with minimum 24-gauge galvanized steel frames. For non-galvanized ductwork, use minimum 1" deep double wall access door with frame that shall use materials of construction identical to adjacent ductwork. Provide double neoprene gasket that shall provide seals from the frame to the door and frame to the duct. When access doors are installed in insulated ductwork or equipment provide insulated doors with insulation equivalent to what is provided for adjacent ductwork or equipment. Access doors constructed with sheet metal screw fasteners will not be accepted.
B. Use insulated 1-1/2 hour UL 1978 listed and labeled access doors in kitchen exhaust ducts.

2.07 FLEXIBLE DUCT

A. Manufacturers: Anco Products, Clevaflex, Thermaflex, Flexmaster, Hart and Cooley.
B. Factory fabricated , UL 181 listed as a class 1 duct, and having a flame spread of 25 or less and a smoke developed rating of 50 or under in accordance with NFPA 90A.
C. Suitable for pressures and temperatures involved but not less than a 180°F service temperature and ±2-inch pressure class, depending on the application.
D. Duct to be composed of polyester film, aluminum laminate or woven and coated fiberglass fabric bonded permanently to corrosion resistant coated steel wire helix. Two-ply, laminated, and corrugated aluminum construction may also be used.
E. Where duct is specified to be insulated, provide a minimum 1-inch fiberglass insulation blanket with maximum thermal conductance of 0.23 K (75 degrees F.) and vapor barrier jacket of polyethylene or metalized reinforced film laminate. Maximum perm rating of vapor barrier jacket to be 0.1 perm.

2.08 FLASHINGS

A. Provide flashing to completely weatherproof connection of ductwork to louvers. Flashing to be constructed of material similar to louver material.
B. Flashing and counterflashing for roof curbs will be provided by others.
C. Flashing and curbs for duct and pipe penetrations of roof assemblies to be in accordance with details.

2.09 DUCT FLEXIBLE CONNECTIONS

A. Material shall be fire retardant, shall be UL 214 listed, and shall meet the requirements of NFPA 90A.
B. Connections to be a minimum of 3 inches wide, crimped into metal edging strip, and air tight. Connections to have adequate flexibility and width to allow for thermal expansion/contraction, vibration of connected equipment, and other movement.
C. Use coated glass fiber fabric for all applications. Material for inside applications other than corrosive environments, fume exhaust, or kitchen exhaust to be double coated with neoprene, air and water tight, suitable for temperatures between -10°F and 200°F and have a nominal weight of 30 ounces per square yard. Material used for outdoor applications other than corrosive environments, fume exhaust, or kitchen exhaust to be double coated with Elastomer, air and water tight, suitable for temperatures between -10°F and 250°F and have a nominal weight of 26 ounces per square yard.

D. For corrosive environments or fume exhaust applications indoors or outdoors, use a material coated with Teflon that is air and water tight, suitable for temperatures between -20°F and 500°F, and has a nominal weight of 14 ounces per square yard.

PART 3 – EXECUTION

3.01 MANUAL VOLUME DAMPERS

A. Install manual volume dampers in each branch duct and for each grille, register, or diffuser as far away from the outlet as possible while still maintaining accessibility to the damper. Install so there is no flutter or vibration of the damper blade(s).

3.02 TURNING VANES

A. Install turning vanes in all rectangular, mitered elbows in accordance with the latest SMACNA standards and/or manufacturer's recommendations.
B. Install double wall, airfoil, 2-inch radius vanes in ducts with vane runner length 18" or greater and air velocity less than 2000 fpm. Install double wall, airfoil, 4-1/2-inch radius vanes in ducts with vane runner length 18" or greater and air velocity 2000 fpm or greater.
C. If duct size changes in a mitered elbow, use single wall type vanes with a trailing edge extension. If duct size changes in a radius elbow or if short radius elbows must be used, install sheet metal turning vanes in accordance with SMACNA Figure 2-5 and Figure 2-6.

3.03 FIRE DAMPERS

A. Install dampers in strict accordance with manufacturer's installation instructions. Install damper sleeves with retaining angles per UL listing. Connections of ductwork to fire damper assemblies to be as specified on the installation instructions. Where it is necessary to set dampers out from the rated wall, install a sleeve extension encased in two hour rated fire proofing insulation. Install an access door at each fire damper, located to permit resetting the damper replacing the fusible link.
B. Manually test each fire damper for proper operation by removing the fusible link. Repair or replace any fire damper that does not close completely. Re-install fusible link after test.

3.04 CONTROL DAMPERS

A. Install dampers in locations indicated on the drawings, as detailed, and according to the manufacturer's instructions. Install blank-off plates or transitions where required for proper mixing of airstreams in mixing plenums. Provide adequate operating clearance and access to the operator. Install an access door adjacent to each control damper for inspection and maintenance.

3.05 SMOKE DETECTORS

A. Duct smoke detector assemblies shall be tested and installed in accordance with the following:
   1. Post air system balancing – testing and adjusting for proper operation shall be done by the installing contractor with a pressure differential manometer.
   2. The differential pressure readings taken across the duct detector housing inlet and return tube shall be between 0.06 minimum and 1.28 maximum inches of water. Provide adjustment to sampling tube as needed to accomplish required pressure differential.
   3. Provide a written record of readings. Submit to the project engineer for review and acceptance prior to the final installation of the duct smoke detector.
   4. Initial tests shall be conducted to qualify installation location suitability. If initial testing concludes appropriate pressure differential may be available, contractor shall install the duct detector assembly complete in accordance with the installation details.
   5. If acceptable differential pressure readings are not obtained, the inlet sampling tube may be rotated until the proper differential pressure readings are obtained. If inlet sampling tube rotation does not yield the proper differential pressure reading, the duct detector assembly shall be relocated further downstream at no additional cost to the owner.
B. Final installation wiring of the duct smoke detector shall not be completed by the electrical contractor until after the proper differential pressure reading has been obtained, documented, and approved.
C. Installation Requirements:

1. In addition to the manufactures instructions the following guidelines will be enforced:
    a. Duct detector may be installed in any wall of the duct unless otherwise restricted by the manufacturer's instructions.
    b. Cut inlet sampling tube length to suite dimension of duct. If duct is more than 18" wide drill an appropriate diameter hole directly opposite to support inlet sampling tube of lengths longer than 18". Sampling tube shall protrude no longer than 1" outside of duct wall.
    c. Contractor to note that air inlet sampling tubes are designed for differing duct widths employing air inlet holes in a quantity matching the duct width. Verify each inlet tube is appropriately sized for the duct width (typically 10 to 12 holes, each 0.193" diameter holes [#11 drill bit]).
    d. Angle cut return tube at a length as recommended by manufacturer if required. Support in accordance with manufacturer's recommendations.
    e. Position inlet holes facing upstream of airflow. This initial installation position shall be used as the starting point for differential pressure testing. If required adjust as stated in the testing/adjusting procedure above. Angle cut of return tube shall be orientated downstream of airflow.
    f. Once acceptable differential pressure readings are obtained, tubes shall be locked in place in accordance with the manufacturer's installation instructions.
    g. Duct detector assembly and sampling tubes shall be mounted rigidly to prevent noise, chatter, and mechanical fatigue. Any installation found unacceptable will be corrected at the installing contractor's expense.
    h. Inlet tubes installed protruding through duct walls greater in width of 18" shall have the sampling tube end plugged with the manufacturer furnished air stopper.
    i. Air leaks are unacceptable, the installing contractor shall provide gaskets, or duct sealant around inlet and outlet air tubes. Sealing around detector housing perimeter is not acceptable. Seal all duct wall penetration to pressure class rating of duct assembly.
    j. Once the detector is installed, verify correct differential pressure readings across sampling tubes and record. Install manufacturer furnished sampling tube filters.
    k. If duct is insulated, provide detector housing standoffs, equivalent in depth of the duct wall insulation, to rigidly support detector assembly. Seal any sampling tube air holes that are not inside duct wall and duct sealant and tape.
    l. At each duct detector installation location provide a service opening. Include a minimum 12" x 12" access door as specified in division 23.
2. After assembly is installed and tested, coordinate with electrical contractor and fire alarm vendor for smoke detector installation.

3.06 ACCESS DOORS

A. Install access doors where specified, indicated on the drawings, and in locations where maintenance, service, cleaning or inspection is required. Examples include, but are not limited to motorized dampers, fire and smoke dampers, smoke detectors, fan bearings, heating and cooling coils, filters, valves, and control devices needing periodic maintenance.

B. Size and numbers of duct access doors to be sufficient to perform the intended service. Minimum access door size shall be 8 x 8-inch size for hand access, 18 x 18-inch size for shoulder access, or other size as indicated. Install access doors on both inlet and outlet sides of reheat coils as well as other duct mounted coils.

C. Label fire, smoke and combination fire smoke dampers on the exterior surface of ductwork directly adjacent to access doors using a minimum of 0.5-inch height lettering reading, "SMOKE DAMPER" or "FIRE DAMPER". Smoke and combination fire smoke dampers shall also include a second line listing the individual damper tag. The tags must be coordinated with the mechanical schedules. Utilize stencils or manufactured labels. All other forms of identification are unacceptable. All labels shall be clearly visible from the ceiling access point.

3.07 FLEXIBLE DUCT

A. Flexible duct may only be used for final connections of air inlets and outlets at diffuser, register, and grille locations. Where flexible duct is used, it shall be the minimum length required to make the final connections, but no greater than 6 feet in length, and have no more than one (1) 90-degree bend.

B. Secure inner jacket of flexible duct in place with stainless steel metal band clamp. Secure insulation vapor barrier jacket in place with steel or nylon draw band. Sheetmetal screws and/or duct tape will not be accepted.
C. Flexible duct used to compensate for misalignment of main duct or branch duct will not be accepted.
D. Individual sections of flexible ductwork shall be of one-piece construction. Splicing of short sections will not be accepted.
E. Flexible ductwork used as transfer duct shall be sized for a maximum velocity of 300 fpm.
F. Penetration of any partition, wall, or floor with flexible duct will not be accepted.

FLASHINGS

G. Flashing for roof curbs, equipment supports, or rails located on roof will be installed by others.

END OF SECTION

SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 **- GENERAL**

1.01 **SCOPE OF WORK**

A. Base Bid: Unless noted otherwise, the Mechanical Contractor shall provide all labor and materials for a complete system in this specification section.

1.02 **SECTION INCLUDES**

A. This section includes specifications for air terminal equipment. Included are the following topics:
   1. Supply Variable Air Volume Boxes
   2. Terminal Air Box Controls
   3. Terminal Unit Insulation

1.03 **RELATED WORK**

A. Applicable provisions of Division 1 govern work under this section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 93 – Testing, Adjusting and Balancing for HVAC
D. Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC
E. Section 23 09 93 – Sequence of Operation for HVAC Controls
F. Section 23 31 00 – HVAC Ducts and Casings
G. Section 23 33 00 – Air Duct Accessories
H. Section 23 82 00 – Heating and Cooling Terminal Units

1.04 **SUBMITTALS**

A. Refer to Section 23 05 00 – Common Work Results for HVAC, Submittals. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Supply Variable Air Volume Boxes
   2. Terminal Air Box Controls
   3. Terminal Unit Insulation
B. Contractor shall submit air terminal unit data including materials of construction, dimensions, scheduled flow rates, pressure drops, radiated and discharge sound power levels, reset volume controller data, actuator spring range and torque data.

1.05 **FUNCTIONAL TESTS**

A. Refer to Section 23 05 00 – Common Work Results for HVAC, Functional Tests. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, perform the following function tests:
   1. Supply Variable Air Volume Boxes
   2. Terminal Air Box Controls
   3. Terminal Unit Insulation

1.06 **REFERENCE STANDARDS**

A. NFPA 90A Installation of Air Conditioning and Ventilation Systems.
B. UL 181 Factory-Made Air Ducts and Connectors.
C. ARI-ADC Standard 880
D. ASTM E84 Surface Burning Characteristics of Building Materials
E. UL 723 Surface Burning Characteristics of Building Materials

1.07 **QUALITY ASSURANCE**

A. Refer to Division 1 for equals and substitutions.

1.08 **DESIGN CRITERIA**

A. Select sizes, capacities, configuration, and operating characteristics as shown on the plans and/or as scheduled.

1.09 **OPERATION AND MAINTENANCE DATA**

A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 – Common Work Results for HVAC.

PART 2 **- PRODUCTS**

2.01 **SUPPLY VARIABLE AIR VOLUME BOXES**

A. Units shall be single duct and pressure independent.
B. Manufacturers: Carnes, Envirotec, Krueger, Metal-Aire, Nailor, Titus, Trane, Price.
C. Construction:
   1. Unit casing shall be minimum 22-gauge steel and internally insulated with 13/16" rigid fiberglass insulation with a foil scrim face or ¾" thick polyolefin closed cell insulation. Construction to meet UL 181 and NFPA 90A. Casing shall be sealed to limit leakage to a maximum of 15 cfm at 6.0 inches of static pressure. Casing outlet shall have slip and drive joint for connection to discharge ductwork.
   2. Metal damper blade shall be mounted to shaft having self-lubricated bearings. Shaft end shall be marked to indicate damper position and shall have a built-in stop to prevent over-stroking. Damper blade shall close off against gasket to limit leakage to 10 cfm at 6.0 inches of differential static pressure. Damper linkage shall be sized to accept at least 40 inch-pounds of torque to the damper shaft. Damper shaft shall be provided with a marking indicating damper position.
   3. Round inlet collar shall be equipped with a multi-point flow sensor that shall amplify the measured velocity pressure. Pneumatic tubing from flow sensor to differential pressure transducer shall be UL listed, fire retardant (FR) type.
D. Hot Water Reheat Coil: Reference section 23 82 00 for Heating and Cooling Terminal Units hot water reheat coil specifications.

2.02 **TERMINAL AIR BOX CONTROLS**

A. DDC Controls:
   1. Butterfly Damper Terminal Air Box: Damper actuator and differential pressure sensor for flow measurement shall be provided under Section 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC.

2.03 **ACCESS DOORS**

A. Refer to Section 23 33 00 – Air Duct Accessories for Access Doors.

2.04 **TERMINAL UNIT INSULATION**

A. Materials or accessories containing asbestos will not be accepted.
B. Use composite insulation systems (insulation, jackets, sealants, and adhesives) that have a flame spread rating of 25 or less and smoke developed rating of 50 or less.
C. The following two internal insulation options may be utilized.
D. Rigid Fiberglass Insulation:
   1. Minimum nominal density of 3 lbs. per cu. ft., and thermal conductivity of not more than 0.23 at 75 degrees F, minimum compressive strength of 25 PSF at 10% deformation, rated for service to 450 degrees F.
   2. Foil-scrim-kraft vapor barrier jacket, factory applied to insulation, maximum permeance of .02 perms. All exposed insulation edges shall be covered with metal nosing.
E. Polyolefin Insulation: Flexible closed cell, minimum nominal density of 1.5 lbs. per cu. ft., thermal conductivity of not more than 0.24 at 75 degrees F, minimum compressive strength of 5 psi at 25% deformation, maximum water vapor permeability of 0.0 per inch, maximum water absorption of 0% by weight and volume, rated for service range of -165 degrees F to 210 degrees F.

PART 3 - **EXECUTION**

3.01 **INSTALLATION**

A. Install air terminal units as indicated on project drawings and in accordance with the manufacturer's installation instructions.

B. Mount air terminal boxes with a minimum 3 feet of straight ductwork upstream of inlet flow sensor for sizes 12" diameter and below. Provide a minimum of 3X the inlet diameter of straight duct upstream of the inlet flow sensor for inlet sizes above 12" diameter.

C. Factory mount coil in supply air terminal unit. Where indicated on drawings field mount coil separate from box with a 12-18" section of duct between the air terminal box and reheat coil. The reheat coil and 12-18" section of duct shall be wrapped with external insulation as indicated in specification section 23 07 00 – HVAC Insulation.

D. Provide at least 24" of clearance on controller side of the air terminal unit. The clearance area shall extend the full length of the supply air terminal unit and the full length (including the access door) of the air terminal unit

E. Support air terminal units from building structure using sheet metal straps or trapeze hanger with rods. Do not mount air terminal units off of adjacent ductwork or piping.

F. Access Doors:

1. Duct Access Doors – Square Duct: Provide duct access doors in duct or extended supply air terminal unit upstream and downstream of the reheat coil. Duct access doors shall be as large as duct allows with a maximum size of 18"x18". Install heating coils in accordance with Section 23 73 12 - Air Handling Unit Coils.
2. Duct Access Doors – Round Duct: Install round duct access doors on the side of the duct upstream of the return/exhaust terminal unit. At no time shall the access door be installed in the bottom of the duct. Piano hinged style access doors shall be installed with the piano hinges located ½ above the bottom of the duct to allow the access door to swing down toward the floor.

G. Insulation:

1. Rigid Fiberglass Insulation: All rigid duct insulation edges shall be covered with metal nosing. Foil scrim face must completely separate the rigid fiberglass duct material from the air stream.
2. Polyolefin Insulation:
   a. Apply full cover coat of adhesive to surface to be insulated, insulation and edge butt joints. Place insulation with edge joints firmly butted pressing to surface for full adhesion. Seal seams and joints vapor tight.
   b. For supply air terminal units, provide five feet of 1" thick lining immediately downstream from air terminal unit discharge. Where hot water re-heat coils are field or factory installed, provide five feet of 1" thick lining in ductwork immediately downstream of reheat coil. Refer to Section 23 33 00 – Air Duct Accessories for liner specification.

3.02 **ADJUSTING**

A. Coordinate adjustment of air terminal units with Section 23 05 93 - Testing, Adjusting and Balancing.

3.03 **TRAINING**

A. See Section 23 05 00 – Common Work Results for HVAC for general training requirements.

B. In addition to the training provided in Section 23 05 00 – Common Work Results for HVAC, provide an additional 1 hour of training for each type of terminal unit provided on the project.

END OF SECTION

SECTION 23 37 13
DIFFUSERS, REGISTERS & GRILLES

PART 1 - GENERAL

1.01 SCOPE OF WORK
A. Base Bid: Unless noted otherwise, the Mechanical Contractor shall provide all labor and materials for a complete system in this specification section.

1.02 SECTION INCLUDES
A. This section includes specifications for air terminal equipment. Included are the following topics:
   1. Square Ceiling Diffusers - High Performance
   2. Square Ceiling Diffusers - Plaque
   3. Square Ceiling Diffusers
   4. Side-Wall Registers and Grilles
   5. Eggcrate Grille

1.03 RELATED WORK
A. Applicable provisions of Division 1 govern work under this section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 93 – Testing, Adjusting and Balancing for HVAC
D. Section 23 31 00 – HVAC Ducts and Casings
E. Section 23 33 00 – Air Duct Accessories

1.04 SUBMITTALS
A. Refer to Section 23 05 00 – Common Work Results for HVAC, Submittals. In addition to the general content specified under Section 20 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Square Ceiling Diffusers - High Performance
   2. Square Ceiling Diffusers - Plaque
   3. Square Ceiling Diffusers
   4. Side-Wall Registers and Grilles
   5. Eggcrate Grille

B. Furnish submittal information including, but not limited to, the following:
   1. Manufacturer's name and model number
   2. Identification as referenced in the documents
   3. Capacities/ratings
   4. Materials of construction
   5. Sound ratings
   6. Dimensions
   7. Finish
   8. Color selection charts where applicable
   9. Manufacturer's installation instructions
   10. All other appropriate data

1.05 REFERENCE STANDARDS
A. NFPA 90A Installation of Air Conditioning and Ventilation Systems.
B. UL 181 Factory-Made Air Ducts and Connectors.
C. ARI-ADC Standard 880

1.06 QUALITY ASSURANCE
A. Refer to Division 1 for equals and substitutions.

1.07 DESIGN CRITERIA

A. All performance data shall be based on tests conducted in accordance with Air Diffusion Council (ADC) Test Code 1062 GRD 84.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Carnes, Krueger, Titus, Metal-Aire, and E.H. Price, and United Sheet Metal.
B. Acceptable manufacturers for specific products are listed under each item.

2.02 SQUARE CEILING DIFFUSERS - HIGH PERFORMANCE

A. High performance type diffuser incorporating short throws and low NC levels. Titus model TMS, Carne series SF, Price model SCD, Metal Aire series 5800, and Krueger series 1400.
B. Diffusers to be 38T unless otherwise indicated, louvered face furnished with frame type appropriate to installation. Refer to architectural plan for ceiling installation conditions types. It is the responsibility of the contractor to coordinate frame and border of diffusers with general contractor.
C. Diffuser shall have throw characteristics of a round diffuser having a 360º horizontal blow pattern.
D. Louver cones shall be one-piece construction with no corner joints.
E. White, baked enamel finish or powder coat finish, unless otherwise indicated.

2.03 SQUARE CEILING DIFFUSERS - PLAQUE

A. Titus model OMNI, Carnes series SFPA/SHPA, Price model SMDP, Metal Aire series 5750, and Krueger series PLQ/5PLQ.
B. 38T unless otherwise indicated, louvered face furnished with frame type appropriate to installation. Refer to architectural plan for ceiling installation conditions types. It is the responsibility of the contractor to coordinate frame and border of diffusers with general contractor.
C. Directional blow pattern as shown on the drawings and/or as scheduled.
D. One-piece removable square face plaque with one-piece back pan.
E. White, baked enamel finish or powder coat finish, unless otherwise indicated.

2.04 SQUARE CEILING DIFFUSERS

A. Titus model TDC/TDC-AA, Carnes series SK or SE, Price model SMD/AMD, Metal Aire series 5500 or 5500S, and Krueger series S.
B. 38T unless otherwise indicated, louvered face furnished with frame type appropriate to installation. Refer to architectural plan for ceiling installation conditions types. It is the responsibility of the contractor to coordinate frame and border of diffusers with general contractor.
C. Directional blow pattern as shown on the drawings and/or as scheduled.
D. One-piece construction louver cones with no corner joints.
E. White, baked enamel finish or powder coat finish, unless otherwise indicated.

2.05 SIDE-WALL REGISTERS AND GRILLES

A. Titus series 300 (supply) and series 350 (return/exhaust), Carnes model R series, Price model 520 (Supply) or 530 (return/exhaust), Metal Aire series V4000 or H4000, Krueger series 880.
B. 38T unless otherwise indicated, with frame type appropriate to installation. Refer to architectural plan for ceiling installation conditions types. It is the responsibility of the contractor to coordinate frame and border of diffusers with general contractor.
C. Double deflection type blade supply registers and supply grilles allow deflection adjustment in all direction.
D. Opposed blade volume control damper supply registers, operable from face.
E. Fixed blade 45 degree core return and exhaust registers and grilles.
F. Opposed blade volume control damper return registers, operable from face.
G. Register and grille sizes as shown on drawings and/or as scheduled.
H. White, baked enamel finish or powder coat finish, unless otherwise indicated.
I. Screw holes on surface counter sunk to accept recessed type screws.

2.06 EGGCRATE GRILLE

A. Titus model 50, Carnes model RAE or RAT, Price model 80, Metal Aire model CC, Krueger model EGC.
B. Aluminum construction with frame type appropriate to installation.
C. Grille face 1/2" x 1/2" or 1" x 1" grid pattern 1" deep with a minimum of 85% free area.
D. Grille sizes and finishes as shown on drawings and/or as scheduled.
E. White, baked enamel finish or powder coat finish, unless otherwise indicated.
F. Refer to architectural plan for ceiling installation conditions types. It is the responsibility of the contractor to coordinate frame and border of diffusers with general contractor.
G. Screw holes on surface counter sunk to accept recessed type screws.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install grilles, registers and diffusers as shown on drawings and according to manufacturer's instructions.
B. Furnish diffusers with equalizing grids where it is not possible to maintain minimum 2 duct diameter straight duct into diffuser. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.
C. Unless otherwise indicated, size ductwork drops to diffusers or grilles to match unit collar size.
D. Seal connections between ductwork drops and diffusers/grilles airtight.
E. Blank off unused portion of linear slot diffusers and linear bar diffusers and grilles.
F. Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.
G. In clean rooms and animal holding rooms, caulk space between diffuser or grille and ceiling or wall to be air and watertight. User clear, non-hardening silicone sealant compatible with ceiling or wall surfaces. Sealant shall be resistant to microbiological growth.

END OF SECTION

SECTION 23 41 00
PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.01 SCOPE OF WORK
A. Base Bid: Unless noted otherwise or referenced from another specification section by a different contractor, the Mechanical Contractor shall provide all labor and materials for a complete system in this specification section.

1.02 SECTION INCLUDES
A. This section includes specifications for air system filters. Included are the following topics:
   1. MERV 7 Filters
   2. Housings for MERV 7 Filters
   3. Side Access Filter Housings
   4. Front Access Filter Holding Frames
   5. Filter Gauges

1.03 RELATED WORK
A. Applicable provisions of Division 1 govern work under this section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 07 00 – HVAC Insulation
D. Section 23 74 13 – Roof Top Air-Handling Units

1.04 SUBMITTALS
A. Refer to Section 23 05 00 – Common Work Results for HVAC, Submittals. In addition to the general content specified under Section 20 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. MERV 7 Filters
   2. Housings for MERV 7 Filters
   3. Side Access Filter Housings
   4. Front Access Filter Holding Frames
   5. Filter Gauges
B. Include data concerning dimensions, materials, efficiencies, installation instructions and appropriate identification.
C. Independent test reports verifying filter performance, test procedures and ratings.

1.05 REFERENCE STANDARDS
A. ASHRAE Standard 52
B. UL 181 – Standard for Factory-Made Air Ducts and Air Connectors
C. UL 586 – Standard for High Efficiency Particulate Air Filter Units
D. UL 900 – Standard for Air Filter Units

1.06 QUALITY ASSURANCE
A. Refer to Division 1 for equals and substitutions.

1.07 DESIGN CRITERIA
A. Use UL Class 1 or Class 2 filters unless noted otherwise.(Reference applicable UL standard referenced)
B. Efficiencies indicated in this section are based on ASHRAE Standard 52.
C. Fan motors have been selected to operate against the resistance of dirty filters as specified in this section.

1.08 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 – Common Work Results for HVAC.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. American Air Filter, Barnebey-Cheney, Cambridge, Continental, Flanders, Camil-Farr, Mine Safety Appliances, Research Products, BLC Industries.
B. Provide fixed filter blockoffs as required to prevent air bypass around filters. Blockoffs shall not need to be removed during filter replacement.

2.02 MERV 7 FILTERS

A. Use 2" thick, pleated panels, 100% synthetic, self-supported media fully bonded and sealed in cardboard frame.
B. Media nominal rating to be 500 FPM face velocity, 0.20-inch WG initial resistance, 1.0 inches WG recommended final resistance., Average arrestance of filter media shall be 90-92%
C. Furnish a side access housing or holding frame as scheduled.
D. Filter tracks shall be constructed to provide a minimum clearance of 2 inches between the pre-filter and final-filter media to facilitate the installation of static pressure tips.

2.03 HOUSINGS FOR MERV 7 FILTERS

A. Housing or holding frame to be of the same manufacturer as filter media or provided by the air handling unit manufacturer. Contractor fabricated housings or filter racks will not be accepted. Casing and tracks constructed of galvanized or enameled steel or aluminum. Provide access to the media tracks from outside the casing so media and be readily changed. Filter tracks shall be constructed to provide a minimum clearance of 2 inches between the pre-filter and final-filter media to facilitate the installation of static pressure tips.

2.04 SIDE ACCESS FILTER HOUSINGS

A. Galvanized steel housing with aluminum or galvanized steel filter mounting tracks. Mounting tracks and access doors to have gaskets to minimize air bypass around the filters. Housing assembly to be suitable for use in duct systems with [based on design]_____ inches of water static pressure.
B. Standard filter sections provided by air handling unit manufacturers may be used for MERV 11 and MERV 14 filters but will not be accepted for HEPA filters or activated carbon filters.
C. Insulate housings where adjacent duct or air handling apparatus is insulated. Insulation to be contained within a 2” thick, double wall steel panel and meet the requirements specified for adjacent duct or apparatus.
D. Furnish a door on each end of the housing to facilitate filter changing. Doors to be hinged and provided with lever handle latches to secure the door. Doors shall not be secured with nuts, bolts, wing nuts, or sheet metal screws.
E. Furnish housings for MERV 11, MERV 14, HEPA filters, or activated carbon filters with a lever action sealing mechanism to secure media in tracks.
F. Filter bypass shall be less than [x]% of design cfm.
G. Include an integral prefilter track for installation of MERV 7 prefilters. Filter tracks shall be constructed to provide a minimum clearance of 2 inches between the pre-filter and final-filter media to facilitate the installation of static pressure tips.

2.05 FRONT ACCESS FILTER HOLDING FRAMES

A. Construct frames of aluminum or corrosion resistant coated steel with provisions for assembly in a bank.
B. Frames for MERV 11 filters, MERV 14 filters, , HEPA filters, and activated carbon filters to have provisions for installation of MERV 7 prefilters upstream of high efficiency media. Secure prefilters by means of spring clips or a spring-loaded mechanism. Spring clips or latches shall be on the

upstream side of the prefilter. Provide leakproof gaskets between prefilter media and holding frame. Prefilters shall be removable without removal of final filters.

2.06 FILTER GAUGES

A. Manufacturers: Dwyer.

B. Each filter section shall be provided with a factory-installed, flush-mounted, direct reading Dwyer 3 ½" type differential pressure gauge with metal case piped to both sides of the filter to indicate status. Gauge shall maintain a +/- 5% accuracy within operating temperature limits of -20° F to 120° F. Filter sections consisting of pre- and post-filters shall have a gauge for each. Lettering shall be black figures on white background. Provide front recalibration adjustment.

C. Provide gauges with the following ranges:

Filter Type	Scale Range (inch W.G.)
MERV 7	0.0 to 1.0

D. Provide one gauge for each filter bank, suitable for flush or surface mounting. Include an air filter gauge accessory package consisting of mounting bracket, aluminum tubing, two static pressure tips, and vent valves for each gauge

PART 3 – EXECUTION

3.01 INSTALLATION

A. Where air handling equipment is to be used for temporary heating or ventilation of a facility, do not operate the equipment until specified filter media has been installed. Contractor shall be responsible for maintaining the cleanliness of air handling apparatus and air distribution systems during construction through regular inspection and changing of filter media throughout the construction period.

B. Where air handling apparatus is used during the construction period, install new filter media prior to start of air balancing. Additionally, deliver one new set of media to the owner prior to substantial completion.

C. Install units as shown on drawings and details according to manufacturer's instructions.

D. Reinforce filter holding frames per manufacturer's instructions.

E. Maintain necessary clearance for changing filters.

3.02 FILTER GAUGES

A. Install filter gauge static pressure tips upstream and downstream of filters. Mount gauge on outside of filter housing or filter plenum in accessible position outside of the unit housing. Install tubing and gauge valves between gauge and sensor tips. Adjust and level each gauge.

3.03 TRAINING

A. See Section 23 05 00 – Common Work Results for HVAC for general training requirements.

B. In addition to the training provided in Section 23 05 00 – Common Work Results for HVAC, provide an additional 1 hours of training for each type of filter housing provided on the project.

END OF SECTION

SECTION 23 74 13
ROOF TOP AIR-HANDLING UNITS

PART 1 – GENERAL

1.01 SCOPE OF WORK
A. Base Bid: Unless noted otherwise, the Mechanical Contractor shall provide all labor and materials for a complete system in this specification section.

1.02 SECTION INCLUDES
A. This section includes specifications for roof top package air-handling units. Included are the following topics:
   1. Units 7-1/2 to 25 Tons

1.03 RELATED WORK
A. Applicable provisions of Division 1 govern work under this section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 13 – Common Motor Requirements for HVAC Equipment
D. Section 23 05 14 – Variable Frequency Drives
E. Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment
F. Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment
G. Section 23 09 93 – Sequence of Operations for HVAC Controls
H. Section 23 31 00 – HVAC Ducts and Casings
I. Section 23 33 00 – Air Duct Accessories
J. Section 23 34 00 – HVAC Fans
K. Section 23 41 00 – Particulate Air Filtration

1.04 SUBMITTALS
A. Refer to Section 23 05 00 – Common Work Results for HVAC, Submittals. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Units 7-1/2 to 30 Tons

B. Submit shop drawings including the following information: specific manufacturer and model numbers, submittal equipment identification corresponding to project drawings and schedules, unit dimensional and weight data, materials of construction, capacities and ratings, fan curves, fan type, drive and motor information, vibration isolation, coil performance data, sound power levels, filter information, information for all accessories.

1.05 FUNCTIONAL TESTS
A. Refer to Section 23 05 00 – Common Work Results for HVAC, FUNCTIONAL TESTS. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, perform the following functional tests:
   1. Units 7-1/2 to 30 Tons

1.06 REFERENCE STANDARDS
A. ARI 430 (latest edition) Standard for Central Station Air Handling Units
B. ARI 210 Unitary Air-Conditioning Equipment.
C. ARI 240 Air Source Unitary Heat Pump Equipment.
D. ARI 270 Sound Rating of Outdoor Unitary Equipment.
E. NFPA 70 National Electrical Code.
F. NFPA 90A Standard for Installation of Air Conditioning and Ventilation Systems

1.07 QUALITY ASSURANCE
A. Packaged air-cooled condenser units shall be certified in accordance with ANSI/AHRI

Standard 340/360 performance rating of commercial and industrial unitary air-conditioning and heat pump equipment.

B. Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.

C. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.

D. Unit shall be certified in accordance with ANSI Z21.47b/CSA 2.3b and ANSI Z83.8/CSA 2.6, Safety Standard Gas-Fired Furnaces.

E. Unit Energy Efficiency Ratio (EER) shall be equal to or greater that prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.

F. Unit shall be safety certified by ETL and ETL US listed. Unit nameplate shall include the ETL/ETL Canada label

1.08 DESIGN CRITERIA

A. Furnish factory fabricated roof top air handling units complete meeting the configuration shown on drawings and/or as scheduled.
B. Units to be tested, rated and certified in accordance with ARI Standard 430 and bear ARI certification label.
C. All material shall meet NFPA 90A flame spread and smoke develop rating requirements.
D. Any revisions made by the Contractor to the inlet and outlet ductwork conditions from that shown on the drawings shall not increase system effect and/or static pressure and shall not decrease mixing efficiencies.

1.09 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 – Common Work Results in HVAC.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Aaon, Valent, Addison, and/or approved equal approved by owner/mechanical engineer.
B. All manufacturers must meet all the specifications below including:

1. Variable capacity compressor with 10-100% capacity control
2. Direct drive supply fans
3. Double wall cabinet construction and insulation with a minimum R-value of 13, with lockable access doors
4. Stainless steel drain pans

2.02 7-1/2 TO 30 TON UNITS

A. General:
1. The units shall be dedicated downflow. Refrigerant shall be R410A. Performance shall be certified in accordance with ARI Standard 210 and 270, American Gas Association, and UL listed. All units shall be factory assembled, internally wired, fully charged with refrigerant and 100 percent run tested to check cooling operation, fan and blower rotation and control sequence, before leaving the factory. Wiring internal to the unit shall be colored and numbered for simplified identification. Units shall be UL listed and labeled with the following information:
   a. Refrigerant
   b. EER
   c. AFUE
2. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, air-cooled condenser coils, condenser fans, gas heaters, exhaust fans, and unit controls.

3. Unit shall be factory assembled and tested including leak testing of the DX coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the service compartment's literature pocket.
4. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
5. Unit components shall be labeled, including refrigeration system components and electrical and controls components.
6. Installation, Operation, and Maintenance manual shall be supplied within the unit.
7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's hinged access door.
8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's hinged access door.

B. Casing/Cabinet:
1. Unit shall be constructed of 18 gauge, G90 galvanized steel with powder coat or baked enamel finish. Unit's finish shall be tested 500 hours minimum in a salt spray test in compliance with ASTM B117. Casing shall be insulated with a minimum of ¾" foil faced fiberglass. Insulation shall be mechanically fastened to the unit. Double wall construction may be used as a substitution.
2. Wall/Roof panel deflection shall not exceed L/240 ratio at a maximum +/- 5 inches of static pressure. Deflection shall be measured at the midpoint of the panel.
3. Base frame shall be constructed of 16-gauge minimum G90 galvanized steel and shall have integral lifting and rigging holes for installation. Base shall overhang roof curb to provide for positive water runoff and weather tight seal.
4. Duct openings in base shall be provided with 1" flange to prevent any water getting into duct system.
5. All access panels shall have gaskets and be provided with fasteners and handles. Panels shall be insulated to match unit construction.
6. Duct sealant and/or gaskets as indicated in Section 23 31 00 – HVAC Ducts and Casings may be utilized to seal duct connections to the roof top air handling unit casing. Silicone sealants are not acceptable. Unit leakage rate shall not exceed 1% of the total system air quantity when subjected to +/- 5" static pressure.

C. Fans:
1. Supply fan wheels shall be backward inclined, forward curved or airfoil type as specified or required by performance characteristics.
2. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure. The motor furnished with the fan shall not operate into the motor service factor when operating under these conditions.
3. Fans to be fastened to hollow or solid steel shafts and designed for continuous operation at maximum rated static pressure. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment. Bearings shall be sized to provide a L-50 life of 250,000 hours.
4. Furnish variable pitch sheaves for drives 3 hp and smaller, fixed pitch sheaves for drives 5 hp and larger. Drives shall be designed for 150% of motor rating. Furnish OSHA approved belt guards for all fans.
5. Condenser fans shall be direct drive, axial type designed for low tip speed and vertical air discharge. Fan blades shall be constructed of steel and riveted to a steel center hub. Condenser fan motors shall be heavy-duty, non-reversing type with permanently lubricated ball bearing and thermal protection. Motor design shall be totally enclosed air over (TEAO) to protect the motors from rain and damage by water.
6. Optional Power relief fans shall be direct drive, centrifugal or axial type designed for horizontal air discharge. Fan motors shall be heavy-duty, non-reversing type with permanently lubricated ball bearing and thermal protection. Motor design shall be totally enclosed air over (TEAO) to protect the motors from rain and damage by water.
7. Fan motors shall be provided in accordance with section 23 05 13 – Common Motor Requirements for HVAC Equipment.

D. Heating (Electric):
1. Provide single stage electric heat as scheduled.

E. Cooling:
   1. Provide a minimum of two steps of cooling capacity with independent refrigeration circuits.
   2. Provide low ambient control to allow mechanical cooling to operate down to 0 degrees F.
   3. Provide unit with a minimum EER per drawings. If EER is not indicated on drawings, the minimum EER shall be equal to or greater than the 2015 International Energy Conservation Code.

F. Compressors:
   1. All units shall have direct-drive, hermetic, scroll type compressors with centrifugal type oil pumps.
   2. Motor shall be suction gas-cooled and shall have Internal overloads shall be provided with the scroll compressors. All models shall have crankcase heaters, phase monitors and low- and high-pressure control as standard.
   3. Provide a time delay between starting of first and second compressor with multiple compressor units.
   4. A lockout timer shall provide a minimum off time of five minutes between compressor cycling.

G. Coils:
   1. Condenser coils shall be multi-row and fabricated from high efficiency copper tubing mechanically bonded to high efficiency aluminum fins. Each condenser coil shall be factory leak tested to 150 psig, pressure tested to 650 psig, and qualified to UL 1995 burst test at 1980 psig. Provide hail guards to protected coils.
   2. Evaporator coils shall be multi-row and fabricated from high efficiency copper tubing mechanically bonded to high efficiency aluminum fins. Each coil shall have interlaced coil circuiting. Each evaporator coil shall be factory leak tested to 150 psig, pressure tested to 450 psig, and qualified to UL 1995 burst test at 1775 psig.
   3. Fabricate cooling coil drain pans from type 304 stainless steel. Install a drain pan under each cooling coil. Extend drain pans the entire width of each coil, including the header, and from the upstream face of each coil to a distance ½ of the vertical coil height of the bottom coil or 6", whichever is greater, downstream from the downstream face. Pitch drain pans in two directions towards the outlet. Pipe drain pans individually down to the drain pan below using a minimum 1" type 304 stainless steel piping. The bottom drain pan shall be piped to the exterior of the unit base.

H. Economizer: **(BAS to control economizer operation)**
   1. BAS to control economizer operation for RTU.
   2. Provide factory installed controls to include modulating outside air dampers, relief fans with dampers and relief hoods.
   3. Unit shall include 0-100% economizer capability as controlled from the BAS consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq. ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly shall be controlled by spring return DDC actuator. Unit shall include outside air opening bird screen, outside air hood, and barometric relief dampers.

I. Electrical:
   1. Provide unit mounted disconnect for a single point power connection.
   2. Provide unit mounted GFI convenience outlet. Outlet shall be powered from unit. Outlet shall be provided with a separate power circuit.

J. Filters:
   1. Unit shall be provided with a draw-through filter section. The filter rack shall be designed to accept a 2" filter. The unit design shall have a hinged access door for the filter section. See Section 23 41 00 – Particulate Air Filtration for filter information.
   2. Unit shall include a clogged filter switch.
   3. Unit shall include a Magnehelic gauge mounted in the controls compartment.

K. Roof Curb:
   1. Provide 12"-15" tall retrofit curb to mate with existing duct configuration and existing curb. Provide new retrofit curb with vibration isolation.

2. Curbs shall to be fully gasketed between the curb top and unit bottom with the curb providing full perimeter support, cross structure support and air seal for the unit. Curb gasket shall be furnished within the control compartment of the rooftop unit to be mounted on the curb immediately before mounting of the rooftop unit.
3. See Sections 23 05 29 – Hangers and Support for HVAC Piping and Equipment and 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment for additional information.

L. Controls:
1. Provide a terminal strip controls interface for field installed controls.
2. Provide space in the RTU control cabinet for a field installed DDC controller. Appx. space to be 18" x 18" or as large as possible for field installed controls.
3. Provide factory installed Wattmaster modulating gas heat controller with supply air temperature sensor. This controller to provide all gas heat functions and safeties in addition to modulating the gas heat to maintain a discharge air temperature and can be reset via a field 0-10V DC input.
4. Provide factory mounted VFD's with 0-10V input signal for controls by others along with a BACnet MS/TP connection for feedback.
5. Provide other control points as indicated in the specifications and shown on the plans.
6. Building BAS shall provide the following outputs for controlling RTU: economizer enable to modulate OA/RA/RE damper per sequence of operations on detail 3/M500, fan enable, the cooling stage 1 on, cooling stage 2 on, heat stage 1on will all be controlled per the supply air temperature control called out under the sequence of operation on detail 3/M500. Building BAS will provide all additional control point as indicated on the points list on detail 4/M500.
7. Refer to Section 23 09 93 - Sequence of Operations for HVAC Controls for Control of discharge temperature, space temperature and fan speed

M. Warranty:
1. Provide a 1-year warranty on unit parts, 5-year warranty on compressors, and 10-year warranty on heat exchanger.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install all roof top air handling units and accessories as indicated on drawings and/or as scheduled and according to manufacturer's installation instructions.
B. Mount units at appropriate height above roof to insure proper condensate trap depth and condensate drainage.
C. Install roof top air handling unit to provide for adequate service access. Coordinate with other trades to assure unit does not infringe upon access or service clearances of other equipment.
D. Lubricate fan bearings. Verify fan isolators have proper deflection and curb mounted spring rail has been installed properly.
E. Upon completion of installation of roof top air handling units, start-up and operate equipment to demonstrate capability and compliance with requirements. Field correct malfunctioning components, then retest to demonstrate compliance.
F. Furnish one spare set of fan drive belts and three reinforced nylon access door handles.

3.02 TRAINING

A. See Section 23 05 00 – Common Work Results for HVAC for general training requirements.
B. In addition to the training provided in Section 23 05 00 – Common Work Results for HVAC, provide an additional 4 hours of training for each type of roof top air-handling unit provided on the project.

END OF SECTION

SECTION 23 82 00
HEATING AND COOLING TERMINAL UNITS

PART 1 – GENERAL

1.01 SCOPE OF WORK
A. Base Bid: Unless noted otherwise, the Mechanical Contractor shall provide all labor and materials for a complete system in this specification section.

1.02 SECTION INCLUDES
A. This section includes specification for heating and cooling terminal equipment using water and/or steam as the source. Included are the following topics:
   1. Reheat Coils
   2. Unit Heaters
   3. Cabinet Heaters

1.03 RELATED WORK
A. Applicable provisions of Division 1 govern work under this Section.
B. Section 23 05 00 – Common Work Results for HVAC
C. Section 23 05 23 – General Duty Valves for HVAC Piping
D. Section 23 09 93 – Sequence of Operations for HVAC Controls
E. Section 23 33 00 – Air Duct Accessories
F. Section 23 41 00 – Particulate Air Filtration

1.04 SUBMITTALS
A. Refer to Section 23 05 00 – Common Work Results for HVAC. In addition to the general content specified under Section 23 05 00 – Common Work Results for HVAC, supply the following submittals:
   1. Reheat Coils
   2. Unit Heaters
   3. Cabinet Heaters

B. Include dimensions, capacities, materials of construction, ratings, weights, wiring diagrams, and appropriate identification for all equipment in this section. Include color selection chart where applicable.

1.05 REFERENCE STANDARDS
A. ARI 210 Standard for Unitary Air-Conditioning Equipment
B. ARI 410 Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
C. CS 140

1.06 QUALITY ASSURANCE
A. Refer to Division 1 for equals and substitutions

1.07 DESIGN CRITERIA
A. Forced Circulation Coils: Ratings certified in accordance with ARI 410.
B. Electrical Equipment and heaters shall be UL listed for the service specified.
C. Electrical components and work must be in accordance with National Electrical Code.

1.08 OPERATION AND MAINTENANCE DATA
A. All operations and maintenance data shall comply with the submission and content requirements specified in Section 23 05 00 – Common Work Results for HVAC.

PART 2 – PRODUCTS

2.01 REHEAT COILS

A. Manufacturers: Carrier, Trane, McQuay, Marlo.
B. Construct coils of copper tubes and aluminum fins in a serpentine arrangement with piping connections on the same end. Provide galvanized steel casing, end supports, top and bottom channels to allowance for expansion of finned tube section. Factory test coils at 200 psig.
C. Headers may be cast iron with tubes expanded into the header, steel pipe with tubes brazed to the header, or seamless copper with tubes brazed to the header.
D. Frames to be flanged for a gasketed connection to adjacent ductwork or constructed for slip and drive connection to the ductwork.
E. Minimum reheat coil size is 8 inches x 8 inches.

2.02 UNIT HEATERS

A. Manufacturers: Modine, McQuay, Trane, Airtherm.
B. Construct casing of 18-gauge steel with baked enamel finish and heating elements of copper tubing with aluminum fins. Use aluminum fan blades, balanced for quiet operation. Provide safety guard for fan/drive assembly. Test coils units at 200 psig.
C. Furnish adjustable horizontal and vertical discharge louvers for units with horizontal discharge. Provide an adjustable cone diffuser for projection units with vertical discharge.
D. Furnish motors with characteristics as scheduled. Single phase, 120-volt motors to be permanently lubricated and provided with thermal overload protection.

2.03 CABINET HEATERS

A. Manufacturers: American Air Filter, Sterling, McQuay, Trane, Airtherm.
B. Construct vertical unit casings with 16-gauge steel front panels and minimum 18-gauge steel end and side panels. Horizontal units located in concealed spaces or mounted in ceiling to have minimum 18-gauge front, end, and side panels.
C. Furnish exposed cabinets in a baked enamel finish in colors selected by the Architect or Owner.
D. Furnish ceiling mounted units with a hinged front panel to allow access to all internal components.
E. Construct heating elements of copper tubes with aluminum fins, tested at 200 psig.
F. Use centrifugal type fans, statically and dynamically balanced to operate without objectionable noise and vibration.
G. Motors to be 120-volt, single phase, permanently lubricated, with thermal overload protection and disconnect switch at unit.
H. Furnish each unit with filter rack and 1" panel filters as specified in Section 23 41 00 – Particulate Air Filtration.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install units in accordance with manufacturer's installation instructions.
B. Install branch water or steam/condensate piping to each unit with a minimum of three elbows to allow for expansion and contraction of the piping system.
C. Coordinate location of units with other trades to assure correct recess size for recessed units.
D. After installation, provide protective covers to prevent accumulation of dirt on units during balance of construction.

3.02 REHEAT COILS

A. Comb bent or crushed fins and clean dust and debris from each coil before enclosing coils in ductwork. Pitch coil casings in accordance with manufacturer's instructions. Install a drain valve on the coil side of the shutoff valves for each reheat coil.
B. Pipe coils with multiple rows for counter flow arrangement.

3.03 UNIT HEATERS

A. Suspend units from building structure and as high as possible to maintain headroom beneath units; supporting from piping systems will not be accepted.
B. Install a drain valve on the coil side of the shutoff valves for each hot water unit heater.

3.04 CABINET HEATERS

A. Mount units in locations indicated on the drawings and as detailed. Install a drain valve on the coil side of the shutoff valves for each hot water cabinet heater.

3.05 TRAINING

A. See Section 23 05 00 – Common Work Results for HVAC for general training requirements.
B. In addition to the training provided in Section 23 05 00 – Common Work Results for HVAC, provide an additional 1 hours of training for each type of heating and cooling terminal unit provided on the project.

END OF SECTION

SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

The electrical work included in all other divisions is the responsibility of the contractor performing the Division 26 work and not the general contractor's responsibility. All Division 26 work is being hired out separately.

PROJECT OVERVIEW

1.01 SCOPE OF WORK

A. The work under this section includes basic electrical requirements, which are applicable to all Division 26 sections. This section includes information common to two or more technical specification sections or items that are of a general nature, not conveniently fitting into other technical sections.

1.02 SECTION INCLUDES

A. Project Overview
B. Scope
C. Related Work
D. Reference Standards
E. Regulatory Requirements
F. Quality Assurance
G. Continuity of Existing Services and Systems
H. Protection of Finished Surfaces
I. Approved Electrical Testing Laboratories
J. Sleeves and Openings
K. Sealing and Fire Stopping
L. Owner Furnished Equipment
M. Intent
N. Omissions
O. Submittals
P. Project/Site Conditions
Q. Work Sequence and Scheduling
R. Work by Other Trades
S. Offsite Storage
T. Salvage Materials
U. Certificates and Inspections
V. Operating and Maintenance Data
W. Record Drawings

1.03 PRODUCTS

A. Access Panels and Doors
B. Identification
C. Sealing and Fire Stopping

1.04 EXECUTION

A. Excavation and Backfill
B. Concrete Work
C. Cutting and Patching
D. Building Access
E. Equipment Access
F. Coordination
G. Sleeves and Openings
H. Sealing and Fire Stopping
I. Housekeeping and Clean Up
J. Agency Training

1.05 RELATED WORK

A. Applicable provisions of Division 1 govern work under this Section.

1.06 REFERENCE STANDARDS

A. Abbreviations of standards organizations referenced in this and other sections are as follows:

1. ANSI American National Standards Institute
2. ASTM American Society for Testing and Materials
3. EPA Environmental Protection Agency
4. ETL Electrical Testing Laboratories, Inc.
5. IEEE Institute of Electrical and Electronics Engineers
6. IES Illuminating Engineering Society
7. ISA Instrument Society of America
8. NBS National Bureau of Standards
9. NEC National Electric Code
10. NEMA National Electrical Manufacturers Association
11. NESC National Electrical Safety Code
12. NFPA National Fire Protection Association
13. UL Underwriters Laboratories Inc.
14. DSPS Wisconsin Department of Safety and Professional Services

1.07 REGULATORY REQUIREMENTS

A. All work and materials are to conform in every detail to applicable rules and requirements of the Wisconsin State Electrical Code (SPS 316), the National Electrical Code (NFPA 70), other applicable National Fire Protection Association codes, the National Electrical Safety Code, and present manufacturing standards (including NEMA).

B. All Division 26 work shall be done under the direction of a currently licensed State of Wisconsin Master Electrician.

1.08 QUALITY ASSURANCE

A. Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the contractor is responsible for all costs involved in integrating the equipment or accessories into the system and the assigned space, and for obtaining the performance from the system into which these items are placed.

B. Manufacturer references used herein are intended to establish a level of quality and performance requirements unless more explicit restrictions are stated to apply.

1.09 CONTINUITY OF EXISTING SERVICES AND SYSTEMS

A. No outages shall be permitted on existing systems except at the time and during the interval specified by the user agency and by the Dane County Project Manager. The institution may require written approval. Any outage must be scheduled when the interruption causes the least interference with normal institutional schedules and business routines. No extra costs will be paid to the Contractor for such outages which must occur outside of regular weekly working hours.

B. This Contractor shall restore any circuit interrupted as a result of this work to proper operation as soon as possible. Note that institutional operations are on a seven-day week schedule.

1.10 PROTECTION OF FINISHED SURFACES

A. Furnish one can of touch-up paint for each different color factory finish furnished by the Contractor. Deliver touch-up paint with other "loose and detachable parts" as covered in the General Requirements.

1.11 APPROVED ELECTRICAL TESTING LABORATORIES

A. The following laboratories are approved for providing electrical product safety testing and listing services as required in these specifications:

1. Underwriters Laboratories Inc.
2. Electrical Testing Laboratories, Inc.

1.12 SLEEVES AND OPENINGS

1.13 SEALING AND FIRE STOPPING

A. Sealing and fire stopping of sleeves/openings between conduits, cable trays, wireways, troughs, cable-bus, busduct, etc. and the sleeve, structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening. Provide all fire stopping of fire rated

penetrations and sealing of smoke rated penetrations in compliance with standard Fire Stopping specifications

1.14 INTENT

A. The Contractor shall furnish and install all the necessary materials, apparatus, and devices to complete the electrical equipment and systems installation herein specified, except such parts as are specifically exempted herein.
B. If an item is either called for in the specifications or shown on the plans, it shall be considered sufficient for the inclusion of said item in this contract. If a conflict exists within the Specifications or exists within the Drawings, the Contractor shall furnish the item, system, or workmanship, which is the highest quality, largest, or most closely fits the owner's intent (as determined by the owner's Project Manager). Refer to the General Conditions of the Contract for further clarification.
C. It must be understood that the details and drawings are diagrammatic. The Contractor shall verify all dimensions at the site and be responsible for their accuracy.
D. All sizes as given are minimum except as noted.
E. Materials and labor shall be new (unless noted or stated otherwise), first class, and workmanlike, and shall be subject at all times to the owner's and A/E's inspections, tests and approval from the commencement until the acceptance of the completed work.
F. Whenever a particular manufacturer's product is named, it is intended to establish a level of quality and performance requirements unless more explicit restrictions are stated to apply.

1.15 OMISSIONS

A. No later than ten (10) days before bid opening, the Contractor shall call the attention of the Dane County Project Manager to any materials or apparatus the Contractor believes to be inadequate and to any necessary items of work omitted.

1.16 SUBMITTALS

A. Submit shop drawings for equipment under each section per requirements listed in that section, as well as per Division 1.
B. Submit for all equipment and systems as indicated in the respective specification sections, marking each submittal with that specification section number. Mark general catalog sheets and drawings to indicate specific items being submitted and proper identification of equipment by name and/or number, as indicated in the contract documents. Failure to do this may result in the submittal(s) being returned to the Contractor for correction and resubmission. Do not submit hard copies of web pages. Failing to follow these instructions does not relieve the Contractor from the requirement of meeting the project schedule.
C. On request from the A/E, the successful bidder shall furnish additional drawings, illustrations, catalog data, performance characteristics, etc.
D. Submittals shall be grouped to include complete submittals of related systems, products, and accessories in a single submittal. Mark dimensions and values in units to match those specified. Include wiring diagrams of electrically powered equipment.
E. The submittals must be approved before fabrication is authorized.
F. Provide electronic copies of all submittals for review.
G. Before submitting electrically powered equipment, verify that the electrical power and control requirements for the equipment are in agreement with the motor starter schedule on the electrical drawings. Include a statement on the shop drawing transmittal to the architect/engineer that the equipment submitted, and the motor starter schedule is in agreement or indicate any discrepancies. See related comments in Section 23 05 13 in Part 1 under Electrical Coordination.
1 copy

1.17 PROJECT/SITE CONDITIONS

A. Install Work in locations shown on drawings, unless prevented by project conditions.
B. Prepare drawings showing proposed rearrangement of work to meet project conditions, including changes to work specified in other sections. Obtain permission of Dane County before proceeding.
C. Tools, materials and equipment shall be confined to areas designated by the user agency.

1.18 WORK SEQUENCE AND SCHEDULING

A. Install work in phases to accommodate user agency's occupancy requirements. During the construction period coordinate electrical schedule and operations with user agency and Dane County.

1.19 WORK BY OTHER TRADES

A. Every attempt has been made to indicate in this trade's specifications and drawings all work required of this Contractor. However, there may be additional specific paragraphs in other trade specifications and addenda, and additional notes on drawings for other trades which pertain to this trade's work, and thus those additional requirements are hereby made a part of these specifications and drawings.

B. Electrical details on drawings for equipment to be provided by others are based on preliminary design data only. This Contractor shall lay out the electrical work and shall be responsible for its correctness to match equipment actually provided by others.

1.20 SALVAGE MATERIALS

A. No materials removed from this project shall be reused unless specifically noted otherwise. All materials removed shall become the property of and shall be disposed of by the Contractor.

1.21 CERTIFICATES AND INSPECTIONS

A. Obtain and pay for all required installation inspections, except those provided by Dane County, in accordance with the Wisconsin Administrative Code. Deliver originals of these certificates to the Dane County Project Representative.

B. The Electrical Contractor is responsible for coordination of all required electrical inspections. Prior to the start of significant on-site electrical work, the contractor shall schedule a pre-installation meeting with any required electrical inspector to discuss the inspection requirements and review the contract requirements. The Electrical Contractor shall be present when the Electrical Inspector conducts the electrical inspections.

1.22 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

B. In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Manufacturer’s wiring diagrams for electrically powered equipment.

1.23 RECORD DRAWINGS

A. The Contractor shall maintain at least one copy each of the specifications and drawings on the job site at all times.

B. Dane County will provide the Contractor with a suitable set of contract drawings on which daily records of changes and deviations from contract shall be recorded. Dimensions and elevations on the record drawings shall locate all buried or concealed piping, conduit, or similar items.

C. The daily record of changes shall be the responsibility of Contractor's field superintendent. No arbitrary mark-ups will be permitted.

D. At completion of the project, the Contractor shall submit the marked-up record drawings to the Architect/Engineer prior to final payment.

PART 2 - PRODUCTS

2.01 ACCESS PANELS AND DOORS

A. Existing Ceilings:

B. Field verify existing ceiling in the pathway of conduits. Provide access panels as required

2.02 IDENTIFICATION

A. See Electrical section 26 05 53 – Identification for Electrical Systems.

2.03 SEALING AND FIRE STOPPING

A. FIRE AND/OR SMOKE RATED PENETRATIONS:

1. Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with state standard specifications.

B. NON-RATED PENETRATIONS:

1. Conduit Penetrations Through Below Grade Walls:

(a) In exterior wall openings below grade, use a modular mechanical type seal consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the uninsulated conduit and the cored opening or water-stop type wall sleeve.

2. Conduit Penetrations:

At conduit and cable tray penetrations of non-rated interior partitions, floors and exterior walls above grade, use urethane caulk in annular space between conduit and sleeve, or the core drilled opening.

PART 3 - EXECUTION

3.01 EXCAVATION AND BACKFILL

A. Perform all excavation and backfill work to accomplish indicated electrical systems installation unless noted otherwise.

3.02 CONCRETE WORK

A. Contractor shall coordinate with the local utility and the owner to provide transformer concrete pad in compliance with the utility standards. Provide all layout drawings, anchor bolts, metal shapes, and/or templates required to be cast into concrete or used to form concrete for the support of electrical equipment.

3.03 CUTTING AND PATCHING

A. Refer to Division 1, General Requirements, Cutting and Patching.

3.04 BUILDING ACCESS

A. Arrange for the necessary openings in the building to allow for admittance of all apparatus. When the building access was not previously arranged and must be provided by this contractor, restore any opening to its original condition after the apparatus has been brought into the building.

3.05 EQUIPMENT ACCESS

A. Install all piping, conduit, ductwork, and accessories to permit access to equipment for maintenance. Coordinate the exact location of wall and ceiling access panels and doors with the General Contractor, making sure that access is available for all equipment and specialties. Where access is required in plaster or drywall walls or ceilings, furnish the access doors to the General Contractor and reimburse the General Contractor for installation of those access doors.

3.06 COORDINATION

A. The Contractor shall cooperate with other trades and Dane County in locating work in a proper manner. Should it be necessary to raise or lower or move longitudinally any part of the electrical work to better fit the general installation, such work shall be done at no extra cost to Dane County, provided such decision is reached prior to actual installation. The Contractor shall check location of electrical outlets with respect to other installations before installing.

B. The Contractor shall verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to light fixtures, panelboards, devices, etc. and recessed or semi-recessed heating units installed in/on architectural surfaces.

C. Coordinate all work with other contractors prior to installation. Any installed work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.

3.07 SLEEVES AND OPENINGS

A. Conduit penetrations in new poured concrete horizontal construction requiring F and T rating: Form opening using hole form or core drill opening. Alternatively provide cast in place fire stopping devices/sleeves.

B. Conduit penetrations in new poured concrete horizontal construction requiring F rating but no T rating: Same as conduit penetrations in new poured concrete construction requiring F and T ratings except that schedule 40 steel pipe sleeves may also be used, where approved by the utility company.

C. Conduit penetrations in new poured concrete horizontal construction that do not require F or ratings: Provide schedule 40 steel pipe sleeve, form opening using hole form or core drill opening.
D. Conduit penetrations in existing concrete floors: Core drill openings.
E. Conduit penetrations through existing floors located in food service areas that do not require a T rating: Core drill sleeve opening large enough to insert schedule 40 sleeve, extend sleeve 2 inches above the floor and grout area around sleeve with hydraulic setting, non-shrink grout.

F. Where penetrating conduit weight is supported by floor, provide manufactured product or structural bearing collar designed to carry load.

3.08 SEALING AND FIRE STOPPING

A. Contractor must seal any conduit opening after removal of existing service feeders.
B. FIRE AND/OR SMOKE RATED PENETRATIONS:
   a. Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with State standard Fire Stopping specifications.
C. NON-RATED PENETRATIONS:
   a. In exterior wall openings below grade, assemble rubber links of mechanical seal to the proper size for the conduit and tighten in place, in accordance with the manufacturer's instructions. Install so that the bolts used to tighten the seal are accessible from the interior of the building or vault.
   b. At all interior walls and exterior walls, conduit penetrations are required to be sealed. Apply sealant to both sides of the penetration in such a manner that the annular space between the sleeve or cored opening and the conduit is completely blocked.
D. PENETRATIONS SUBJECT TO WATER INTRUSION:
   a. For penetrations (both rated and non-rated) in floors subject to water intrusion or in rooms housing electrical equipment (but not within walls) provide one of the following:
      1. Conduit penetration where steel pipe sleeve is used extend steel sleeve 2” above the floor.
      2. Conduit penetration where cast in place fire stopping device/sleeve is used, extend device/sleeve 2” above the floor (provided it meets the device’s UL listing).
      3. Conduit penetration where there is no steel sleeve or cast in place fire stopping device/sleeve, provide 2”x 2” x 1/8” galvanized steel angles fastened to surrounding the penetration or group of penetrations to prevent water from getting to floor penetration. Provide urethane caulk between angles and floor and fasten angles to floor minimum 8”on center. Seal corners water tight with urethane caulk.
   b. Floors subject to water intrusion or rooms housing electrical equipment include the following locations:
      1. Mechanical/Plumbing Equipment Rooms
      2. Maintenance/Industrial Shops
      3. Electrical Equipment Rooms
E. Provide waterproof caulk sealant top coating on fire stopping system (or other approved means to protect the fire stopping system from water) in areas subject to wash down such as Food Service and Dish Washing Areas.

3.09 HOUSEKEEPING AND CLEAN UP

A. The Contractor shall clean up and remove from the premises, on a daily basis, all debris and rubbish resulting from its work and shall repair all damage to new and existing equipment resulting from its work. When job is complete, this Contractor shall remove all tools, excess material and equipment, etc., from the site.

3.10 AGENCY TRAINING

A. All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under the general conditions by Dane County.

B. Contractor to provide factory authorized representative and/or field personnel knowledgeable with

the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 2 hours.

END OF SECTION

SECTION 26 05 04
CLEANING, INSPECTION, AND TESTING OF ELECTRICAL EQUIPMENT

PART 1 - GENERAL
Scope
Related Work
PART 2 - PRODUCTS
Not Used
PART 3 - EXECUTION
General Inspection and Cleaning of All Electrical Equipment
Grounding Systems
Metering and Instrumentation
Mechanical and Electrical Interlock System
Panelboards
Cables

1.01 SCOPE

A. The work under this section includes the required cleaning, inspection, adjustment, maintenance and testing of electrical equipment, as specified herein. This applies only to new electrical and existing electrical equipment being furnished, modified, worked on or serviced by this contractor for this project. Included are the following topics:

1.02 RELATED WORK

A. Applicable provisions of Division 1 govern work under this Section.

PART 2 - PRODUCTS

Not used

PART 3 - EXECUTION

3.01 GENERAL INSPECTION AND CLEANING OF ALL ELECTRICAL EQUIPMENT

A. Inspect for physical damage and abnormal mechanical and electrical conditions.
B. Any item found to be out of tolerance, or in any other way defective as a result of the required inspection or testing, shall be reported to the Dane County. Procedure for repair and/or replacement will be outlined. After appropriate corrective action is completed the item shall be re-tested.
C. Compare equipment nameplate information with the latest single line diagram and report any discrepancies.
D. Verify proper auxiliary device operation and indicators.
E. Check tightness of accessible bolted electrical joints. Use torque wrench method.
F. Make a close examination of equipment and remove any shipping brackets, insulation, packing, etc. that may not have been removed during original installation.
G. Make a close examination of equipment and remove any dirt or other forms of debris that may have collected in existing equipment or in new equipment during installation.
H. Clean All Equipment:
    a. Vacuum inside of panelboards, C/T cabinet, fire alarm panels, etc.
    b. Loosen attached particles and vacuum them away.
    c. Wipe all insulators with a clean, dry, lint free rag.
    d. Clean insulator grooves.
    e. Re-vacuum inside surfaces as directed by the Dane County Field Representative or Inspector
    f. Exercise all existing circuit breakers and tighten all terminal connections.
I. Inspect equipment anchorage.
J. Inspect equipment and bus alignment.
K. Check all heater elements for operation and control.
L. Lubricate nonelectrical equipment per manufacturer's recommendations.

3.02 GROUNDING SYSTEMS

A. Inspect the ground system for adequate termination at all devices.

3.03 METERING AND INSTRUMENTATION

A. Examine all devices for broken parts, damage and wire connection tightness.
B. Verify the electronic meter is connected properly and displaying proper voltage and power quantities.
C. Inspect nameplate information for compatibility with one-line drawings.
D. Verify the instrument transformer connections with the system requirements.
E. Verify tightness of all bolted connections and assure adequate clearances exist from primary circuits to secondary circuit wiring and to grounds.
F. Verify that all required grounding and shorting connections exist and that those connections make good contact; i.e. sufficient surface area, good cleanliness, and proper pressure.
G. Verify proper primary and secondary fuses and required sizes.

3.04 MECHANICAL AND ELECTRICAL INTERLOCK SYSTEM

A. Physically test each system to insure proper function, operation and sequencing.
B. Closure attempt shall be made on locked open devices.
C. Opening attempt shall be made on locked closed devices.
D. Key exchange shall be made with devices operated in off normal positions.

3.05 PANELBOARDS

A. Torque all the connections per the manufacturers spec. Verify phase wires, color coding, separate neutral and mechanical bonding. Verify circuit breaker operation. Verify the directory.
B. Vacuum clean the panelboard enclosure.

3.06 CABLES

A. 600 Volt cable:
    1. Visually inspect cables, lugs, connectors and all other components for physical damage and proper connections.
    2. Check all cable connectors for tightness (with a torque wrench) and clearances. Torque test conductor terminations to manufacturer's recommendations.
    3. Perform a 1000 Vdc megger test on all secondary cables from the substation transformers to the secondary switchboards and on all switchboard feeders.

END OF SECTION

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL
Scope
Related Work
References
Submittals
Project Conditions
PART 2 - PRODUCTS
General
Building Wire
Service Entrance Conductors
Aboveground Wire for Exterior Work
Underground Wire for Exterior Work
Wiring Connectors
PART 3 - EXECUTION
General Wiring Methods
Wiring Installation in Raceways
Wiring Connections and Terminations
Field Quality Control
Wire Color
Branch Circuits
Construction Verification Items

PROJECT OVERVIEW

1.01 SCOPE OF WORK
A. The work under this section includes furnishing and installing required wiring and cabling systems including pulling, terminating and splicing. Included are the following topics:

1.02 RELATED WORK
A. Applicable provisions of Division 1 govern work under this Section.
B. Section 26 05 33 – Raceway and Boxes for Electrical Systems.
C. Section 26 05 53 – Identification for Electrical Systems.
D. Section 26 08 00 - Commissioning of Electrical.

1.03 REFERENCES
A. SPS 316- Electrical

1.04 SUBMITTALS
A. Submit product data: Provide for each cable assembly type.
B. Submit factory test reports: Indicate procedures and values obtained.
C. Submit shop drawings for modular wiring system including layout of distribution devices, branch circuit conduit and cables, circuiting arrangement, and outlet devices.
D. Submit manufacturer's installation instructions. Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.

1.05 PROJECT CONDITIONS
A. Verify that field measurements are as shown on Drawings.
B. Conductor sizes are based on copper.
C. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required for project conditions.
D. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

PART 2 - PRODUCTS

2.01 GENERAL
A. All wire shall be new, delivered to the site in unbroken cartons and shall be less than one year old out of manufacturer's stock.
B. All conductors shall be copper.
C. Insulation shall have a 600 volt rating.

D. All conductors shall be stranded.
    1. Stranded conductors may only be terminated with UL OR ETL Listed type terminations or methods: e.g. stranded conductors may not be wrapped around a terminal screw but must be terminated with a crimp type device or must be terminated in an approved back wired method.

2.02 BUILDING WIRE

A. Description: Single conductor insulated wire 90 degree C.
B. Insulation: Type THHN/THWN-2, XHHW-2 insulation.

2.03 SERVICE ENTRANCE CONDUCTORS

A. Description: Single conductor or multi-conductor insulated wire. 90 degree C sized at the 75 degree C table.
B. Insulation: Type XHHW-2 insulation for service entrance conductors routed from exterior source to exterior termination location.
    1. Type XHHW-2 insulation for services entrance conductors routed from exterior source to interior termination location.

2.04 ABOVEGROUND WIRE FOR EXTERIOR WORK

A. Description: Single conductor insulated wire, 90 degree C.
B. Insulation: Type XHHW-2 insulation.

2.05 UNDERGROUND WIRE FOR EXTERIOR WORK

A. Description: Stranded single or multiple conductor insulated wire, 90 degree C.
B. Insulation: Type XHHW-2insulation.
C. This wiring shall be used in all underground feeder and branch circuit applications, except THHN/THWN-2 is permitted when run in a concrete-encased duct bank.

2.07 WIRING CONNECTORS

A. Split Bolt Connectors: Not acceptable.
B. Solderless Pressure Connectors: High copper alloy terminal. May be used only for cable termination to equipment terminals. Not approved for splicing.
C. Twist Type Wire Connectors: Solderless twist type spring connector (wire-nut) with insulating cover for copper wire splices and taps. Use for conductor sizes 10 AWG and smaller. The manufacturer's wire fill capacity must be followed. Use Silicone filled twist type spring connectors in all wet location areas.
D. All wire connectors used in underground or exterior pull boxes or hand holes shall be gel filled twist connectors or a connector designed for damp and wet locations. Gel filled twist type connectors can be used for copper conductor sizes 6 AWG and smaller for site lighting applications. The manufacturer's wire fill capacity must be followed.
E. Mechanical Connectors: Bolted type tin-plated; high conductivity copper alloy; spacer between conductors; beveled cable entrances.
F. Compression (crimp) Connectors: Long barrel; seamless, tin-plated electrolytic copper tubing; internally beveled barrel ends. Connector shall be clearly marked with the wire size and type and proper number and location of crimps. Connector must be installed with a crimper tool listed for use with the manufacturer and type of compression connector.
G. Insulation Piercing Connectors: Molded insulated body, copper teeth, wrench tightened, UL 486B Listed. May be used only for connection of a tap conductor in run and tap type applications when main conductor is 8 AWG and larger.

PART 3 - EXECUTION

3.01 GENERAL WIRING METHODS

A. All wire and cable shall be installed in conduit.
B. Do not use wire smaller than 12 AWG for power and lighting circuits.
C. All phase, neutral and ground conductors shall be sized to prevent excessive voltage drop at rated circuit ampacity. As a minimum use 10 AWG conductors for 20 ampere, 120 volt branch circuit home runs longer than 100 feet (30 m), and for 20 ampere, 277 volt branch circuit home runs longer than 200 feet (61 m).
D. Ground conductor size shall be increased per NEC 250.122(B) when phase and phase/neutral conductors are increased in size.
E. Make conductor lengths for parallel conductors equal.
F. Splice only in junction or outlet boxes.

G. No conductor less than 10 AWG shall be installed in exterior underground conduit.
H. Identify ALL low voltage wire, 600V and lower, per section 26 05 53.
I. Neatly train and lace wiring inside boxes, equipment, and panelboards.

3.02 WIRING INSTALLATION IN RACEWAYS

A. Pull all conductors into a raceway at the same time. Use Listed water or silicone based wire pulling lubricant for pulling 4 AWG and larger wires and for other conditions when necessary. Wax based lubricants are not allowed. Pulling lubricant is not required for low friction type products where the cable manufacturer recommends that cables be pulled without lube.
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. Completely and thoroughly swab raceway system before installing conductors.
D. Place all conductors of a given circuit (this includes phase wires, neutral (if any), and ground conductor) in the same raceway. If parallel phase and/or neutral wires are used, then place an equal number of phase and neutral conductors in same raceway or cable.
E. VFD Installations: Install VFD input wiring and output wiring in separate conduit systems. Do not mix VFD input power and output power, or control wiring in a common raceway.
F. In high ambient spaces, mechanical rooms, utility rooms and exterior exposed conduit, 90 degree C, XHHW-2 conductors shall be utilized.
G. Parallel runs of power feeders shall be of the same type and manufactured in the same batch. These feeders shall be of equal length and must inspected by local inspector for before and after the terminations.

3.03 WIRING CONNECTIONS AND TERMINATIONS

A. Splice only in accessible junction boxes.
B. Wire splices and taps shall be made firm, and adequate to carry the full current rating of the respective wire without soldering and without perceptible temperature rise.
C. All splices shall be so made that they have an electrical resistance not in excess of two feet (600 mm) of the conductor.
D. Use solderless twist type spring connectors (wire nuts) with insulating covers for wire splices and taps, 10 AWG and smaller.
E. Use mechanical or compression connectors for wire splices and taps, 8 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of the wiring.
F. Thoroughly clean wires before installing lugs and connectors.
G. At all splices and terminations, leave tails long enough to cut splice out and completely re-splice.

3.04 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 26 05 04.
    1. Conductors shall be closely checked for loose or poor connections, and for signs of overheating or corrosion.
    2. Test procedures shall meet NETA guidelines.
    3. Test results and report shall be provided to the engineer and included in O&M manual under AL conductors/ tests.
    4. Contractor shall correct all deficiencies reported in the test report.

3.05 WIRE COLOR

A. General:
    1. Solid colored insulation is required for all THHN/THWN-2 wire. For other wire types use colored wire or identify wire with colored tape at all terminals, splices and boxes. Wire shall be colored as indicated below.
    2. In existing facilities, use existing color scheme.
    3. In new facilities, use black and red for single phase circuits at 120/240 volts, use Phase A black, Phase B red and Phase C blue for circuits at 120/208 volts single or three phase Note: This includes fixture whips except for Listed whips mounted by the fixture manufacturer on the fixture and Listed as a System.
    4. Switch legs shall be the same color as their associated circuit, except for the second switch leg used for dual-level switching.
    5. Traveler conductors run between 3- and 4-way switches shall be colored pink or purple.
B. Neutral Conductors: White for 120/208V systems. Where there are two or more neutrals in one conduit, each shall be individually identified with a different stripe.
C. Branch Circuit Conductors: Three or four wire home runs shall have each phase uniquely color coded.

D. Feeder Circuit Conductors: Each phase shall be uniquely color coded.
E. Ground Conductors: Green colored insulation for THHN/THWN-2 wire. For other wire types use green colored wire or identify wire with green tape at both ends and at all access points, such as panelboards, motor starters, disconnects and junction boxes. When isolated grounds are required, contractor shall provide green with yellow tracer.

3.06 BRANCH CIRCUITS

A. The use of single-phase, multi-wire branch circuits with a common neutral is not permitted. All single-phase branch circuits shall be furnished and installed with an individual accompanying neutral, sized the same as the phase conductors.

END OF SECTION

SECTION 26 05 23
CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 – GENERAL

1.01 SCOPE OF WORK
A. Base Bid: The work under this section includes furnishing and installing required remote control and signal cabling.

1.02 SECTION INCLUDES
A. General
B. Manufacturers
C. Remote Control and Signal Cable
D. Wiring Connectors

1.03 RELATED WORK
A. Drawings and general provisions of the Contract, including BASIC REQUIREMENTS and Division 01 Specification Sections, apply to this Section.
B. Section 26 05 00 – Common Work Results for Electrical
C. Section 26 05 33 – Raceway and Boxes for Electrical Systems
D. Section 26 05 53 – Identification for Electrical Systems

1.04 SUBMITTALS
A. Submit product data: Provide for each cable assembly type.
B. Submit manufacturer's installation instructions. Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.

1.05 REFERENCE STANDARDS
A. NFPA 70 - National Electrical Code

1.06 FUNCTIONAL PERFORMANCE TEST
A. Refer to Section 26 05 00 – Common Work for Electrical – Functional Performance Test.
B. A continuity check shall be performed on control and instrumentation wiring.

1.07 PROJECT CONDITIONS
A. Verify that field measurements are as shown on Drawings.
B. Conductor sizes are based on copper.
C. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project Conditions.
D. Where wire and cable routing are not shown, and destination only is indicated, determine exact routing and lengths required.

PART 2 – PRODUCTS

2.01 GENERAL
A. All wire shall be new, delivered to the site in unbroken cartons and shall be less than one year old out of manufacturer's stock.
B. All conductors shall be copper.
C. Insulation shall have a 600-volt rating.
D. All conductors must be suitable for the application intended. Conductors #12 and smaller may be solid or stranded with the following requirements or exceptions:
E. All conductors terminated with crimp type devices must be stranded.

F. Stranded conductors may only be terminated with UL OR ETL Listed type terminations or methods: e.g. stranded conductors may not be wrapped around a terminal screw but must be terminated with a crimp type device or must be terminated in an approved back wired method.

2.02 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
   1. Alcan Products Corporation; Alcan Cable Division
   2. American Insulated Wire Corp.; a Leviton Company
   3. General Cable Corporation
   4. Senator Wire & Cable Company
   5. Southwire Company
   6. Houston Wire & Cable
   7. Insert Manufacturer's Name

2.03 REMOTE CONTROL AND SIGNAL CABLE

A. Refer to Section 28 31 00 for requirements for cable to be used on fire alarm systems.
B. Refer to Mechanical specifications section for HVAC system related control wiring.
C. Control Cable for Class 1 Remote Control and Signal Circuits: 600-volt insulation, individual conductors twisted together, [shielded], and covered with an overall PVC jacket. Cable shall be Listed, temperature rated, and plenum or non-plenum rated for the application as required in the National Electrical Code.
D. Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits shall be constructed, Listed, temperature rated, and plenum or non-plenum rated for the application as required in the NEC Article 725.
E. , Fire alarm cable type FPL 75C (UL) R19359 classified 2-hour fire rating/system 24.

2.04 WIRING CONNECTORS

A. Split Bolt Connectors: Not acceptable.
B. Spring Wire Connectors: Solderless spring type pressure connector with insulating covers for copper wire splices and taps. Use for conductor sizes 10 AWG and smaller.
C. All wire connectors used in underground or exterior pull boxes shall be gel filled twist connectors or a connector designed for damp and wet locations.

PART 3 – EXECUTION

3.01 GENERAL WIRING METHODS

A. Low voltage control and signal cables shall be installed in conduit. However, they may be installed without conduit above accessible ceilings if the cable meets NEC requirements for the application, unless specified to be in conduit in other sections of the specifications. See requirements for free-air cabling installation below.
B. Control cables for controlling HVAC and lighting equipment connected to emergency power shall be routed in raceway.
C. Do not use wire smaller than 14 AWG for control wiring greater than 60 volts, or 18 AWG for voltages less than 60 volts, all sizes subject to NEC 725 requirements.
D. Splice only in junction boxes.
E. Identify wire per section 26 05 53.
F. Neatly train and lace wiring inside boxes, and equipment.

3.02 WIRING INSTALLATION IN RACEWAYS

A. Pull all conductors into a raceway at the same time. Use Listed wire pulling lubricant for pulling conditions when necessary.
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. Completely and thoroughly swab raceway system before installing conductors.

3.03 FREE-AIR CABLE INSTALLATION

A. When permitted in exposed ceiling areas, 'Free-Air' wiring runs shall avoid areas of high traffic (i.e. aisle way), shall be run as close as possible to outlining walls and shall be a minimum of ten (10) feet above finished floor.
B. Cabling shall be neatly run at right angles and be kept clear of other trades work.
C. Cabling shall be supported at a maximum of 4-foot intervals utilizing 'bridal-type' mounting rings anchored to ceiling concrete, piping supports or structural steel beams. If cable sag at mid-span exceeds 12-inches, another support shall be provided. Mounting rings shall be designed to maintain cables bend to larger than the minimum bed radius (typically 4 x cable diameter).
D. Cabling shall not be attached to or supported by existing cabling, plumbing or steam piping, ductwork, suspended ceiling supports or electrical conduit. Additionally, cabling shall not be laid directly on the ceiling grid.
E. To reduce or eliminate Electro-Magnetic Interference (EMI), the following minimum separation distances for 'Free-Air' cabling installations shall be adhered to:
    1. Twelve (12) inches from power lines of less than 5kV.
    2. Thirty-nine (39) inches from power lines of 5kV or greater.
    3. Eighteen (18) inches from lighting fixtures.
    4. Thirty-nine (39) inches from transformers and motors.
F. A coil of 2 feet in each cable shall be placed in the ceiling at each 'free-air' wired device. These coils shall be secured (wire tied) at the last cable support before the cable reaches the device and shall be coiled from 100% to 200% of the cable recommended minimum bend radius.
G. All cable shall be free of tension at both ends. Nylon strain relief connectors shall be provided at each device and junction box where cables enter. In cases where the cable must bear some stress, Kellum type grips may be used to spread the strain over a longer length of cable.
H. Cable manufacturers minimum bend radius shall be observed in all instances. Care should be taken in the use of cable ties to secure and anchor the station cabling. Ties should not be over tightened as to compress the cable jacket. No sharp burrs should remain where excess length of the cable tie has been cut.
I. All exposed vertical cable extensions to devices located below the finished ceiling shall be in conduit.
J. Provide protection for exposed cables where subject to damage.
K. Use suitable cable fittings and connectors.

3.04 WIRING CONNECTIONS AND TERMINATIONS

A. Splice only in accessible junction boxes.
B. All splices shall be so made that they have an electrical resistance not in excess of two feet (600 mm) of the conductor.
C. Use solderless spring type pressure connectors with insulating covers for wire splices and taps, 10 AWG and smaller.
D. Thoroughly clean wires before installing lugs and connectors.
E. At all splices and terminations, leave tails long enough to cut splice out and completely re-splice.

3.05 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 26 05 04.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL
Scope
Related Work
References
Performance Requirements
Submittals
Project Record Documents
Regulatory Requirements
PART 2 - PRODUCTS
Rod Electrode
Concrete-Encased Grounding Electrode
Mechanical Connectors
Compression Connectors
Exothermic Connections
Conductors
Bus/Busbar
PART 3 - EXECUTION
Examination
General
Less Than 600 Volt System Grounding
Field Quality Control
Identification and Labeling
Construction Verification Items
Warranty

All hardware, cables and related termination and support hardware shall be furnished, installed, wired, tested, labeled, and documented by the Contractor, as detailed in this and related sections.

1.01 SCOPE

A. The work under this section includes grounding electrodes and conductors, equipment grounding conductors, and bonding for Electrical and Communications systems.

1.02 RELATED WORK

A. Applicable provisions of Division 1 govern work under this Section.
B. Section 26 08 00 - Commissioning of Electrical.

1.03 REFERENCES

A. ANSI/IEEE 142 (Latest edition) - Recommended Practice for Grounding of Industrial and Commercial Power Systems
B. UL 467 Electrical Grounding and Bonding Equipment
C. IEEE 837 - IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding
D. TIA-607-C - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

1.04 PERFORMANCE REQUIREMENTS

A. Grounding System Resistance:
    1. Equipment Rated 500 KVA and Less: 10 ohms maximum at building service entrance.
    2. Equipment Rated 500 to 1000 KVA: 5 ohms maximum at building service entrance.
    3. Equipment Rated more than 1000 KVA: 3 ohms building service entrance.
    4. Communications Busbars: 5 ohms maximum.
B. Provide test report of grounding system overall resistance and resistance of each electrode in final O&M manuals and noted on record documents.

1.05 SUBMITTALS

A. Product Data: Provide data for grounding electrodes and connections.
B. Provide samples of ground labels.

C. Test Reports: Indicate overall resistance to ground [and resistance of each electrode].
D. Manufacturer's Instructions: Include instructions for preparation, installation and examination of exothermic connectors.

1.06 PROJECT RECORD DOCUMENTS

A. Record locations of all electrical and telecommunications grounding electrodes, busbars and grounding conductors as installed including recorded ground resistance test results.

1.07 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. or testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

PART 2 - PRODUCTS

2.01 ROD ELECTRODE

A. Material: Copper-clad steel.
B. Diameter: 3/4 inch (19 mm) minimum.
C. Length: 10 feet (3.5 m) minimum. Rod shall be driven at least 9' 6" deep.

2.03 MECHANICAL CONNECTORS

A. The mechanical connector bodies shall be manufactured from high strength, high conductivity cast copper alloy material. Bolts, nuts, washers and lock washers shall be made of Silicon Bronze and supplied as a part of the connector body and shall be of the two bolt type.
B. Split bolt connector types are NOT allowed. Exception: the use of split bolts is acceptable for grounding of wire-basket type cable tray, and for cable shields/straps of medium voltage cable.
C. The connectors shall meet or exceed UL 467 and be clearly marked with the catalog number, conductor size and manufacturer.

2.04 COMPRESSION CONNECTORS

A. The compression connectors shall be manufactured from pure wrought copper. The conductivity of this material shall be no less than 99% by IACS standards.
B. Each connector shall be factory filled with an oxide-inhibiting compound.
C. The connectors shall meet or exceed the performance requirements of IEEE 837, latest revision.
D. The connectors shall be clearly marked with the manufacturer, catalog number, conductor size and the required compression tool settings.
E. The installation of the connectors shall be made with a compression tool and die system, as recommended by the manufacturer of the connectors, and shall be irreversible.
F. Pre-crimping of the ground rod is required for all irreversible compression connections to a ground rod.
G. Terminal lug for communication system grounding shall be compression type and conform to the following:
    1. Material: Tin Plated Copper (aluminum not permitted).
    2. Wire Size: to match conductor
    3. Number of Stud Holes: 2
    4. Stud Hole Size: 3/8”
    5. Bolt Hole Spacing: per TIA-607-C
    6. Tongue Angle: Straight

2.05 EXOTHERMIC CONNECTIONS

A. As manufactured by Erico Cadweld, Harger Ultraweld or similar.

2.07 CONDUCTORS

A. Material: Stranded copper (aluminum not permitted).
B. Grounding Electrode Conductor: Bare seven-strand conductors. Size as shown on drawings, specifications or as required by NFPA 70, whichever is larger.
C. Foundation Electrodes: As shown on drawings.
D. Primary Manhole, Main Switchgear room and Vault Bonding: No. 4/0 minimum.
E. Feeder and Branch Circuit Equipment Ground: Size as shown on drawings, specifications or as required by NFPA 70, whichever is larger. Differentiate between the normal ground and the isolated ground when both are used at the same facility.

F. Branch Circuit Equipment Ground shall be proportionately increased in size when routed with phase conductors increased in size.
G. Conductors for Telecommunications shall be as follows:
    1. Telecommunications Bonding Conductor (TMGB to Service Ground): No. 3/0 minimum or as shown on drawings.
    2. Telecommunications Bonding Backbone (TBB; TMGB to TGB): No. 3/0 minimum or as shown on drawings.
    3. Telecommunications Grounding Equalizer (GE): No. 3/0 minimum or as shown on drawings.
    4. Bonding Conductors shall be insulated with a Green Jacket or jacket marked with Green Tape or labeled per NEC Guidelines.

2.08 BUS/BUSBAR

A. Material: Copper (aluminum not permitted).
B. Size:
    1. All Power systems: 1/4" X 2", length as needed (24” minimum).
    2. Telecommunications Main Ground Busbar (TMGB): Field locate existing to extend connections to new Grounding system.
    3. Telecommunications Grounding Busbar (TGB):
    4. Field locate existing to extend connections to new Grounding system.
C. Busbars:
    1. Be pre-drilled to accommodate two-hole lugs.
    2. 3/8” stud hole size; hole spacing per TIA-607-C.
    3. Incorporate insulators and stand-off brackets that electrically isolate busbar from mounting surface.
D. Provide main ground busbar located adjacent to main electrical service equipment to terminate all ground conductors.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that final backfill and compaction has been completed before driving rod electrodes.

3.02 GENERAL

A. Install Products in accordance with manufacturer's instructions.
B. Mechanical connections shall be accessible for inspection and checking. No insulation shall be installed over mechanical ground connections.
C. Ground connection surfaces shall be cleaned and all connections shall be made so that it is impossible to move them.
D. Attach grounds permanently before permanent building service is energized.
E. Terminate each grounding conductor on its own terminal lug. Sharing a single lug by multiple conductors is not allowed.
F. All grounding electrode conductors and individual grounding conductors shall be installed in PVC conduit, in exposed locations.
G. Each grounding electrode conductor shall be labeled at each terminated end as to system served and location of second termination.

3.03 LESS THAN 600 VOLT ELECTRICAL SYSTEM GROUNDING

A. Supplementary Grounding Electrode: [Use driven ground rod on exterior of building.] [Use effectively grounded metal frame of the building.]
B. Provide code sized copper grounding electrode conductor from electrical room ground bus to secondary switchboard ground bus, each separately derived system neutral, secondary service system neutral to street side of water meter, building steel, ground rod, and any concrete encased electrodes. Provide bonding jumper around water meter. Provide physical protection as required.
C. Equipment Grounding Conductor: Provide separate, insulated equipment grounding conductor within each raceway. Terminate each end on suitable lug, bus, enclosure or bushing. Provide a ground wire from each device to the respective enclosure.

D. Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.
E. Install new service grounding where indicated in compliance with NEC and local standards Water main and building steel ground conductor shall be 3/0 minimum and #4 AWG bare copper for the ground rod connections.
F. Bond together each metallic raceway, pipe, duct and other metal object entering space under access floors. Bond to under floor ground grid. Use # AWG bare copper conductor.

3.04 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.
B. Testing of grounding system resistance is to be witnessed by the Electrical Inspector or Construction Representative. Provide test report of grounding system resistance in final O&M manuals and noted on record drawings.
C. Provide resistance test at each electrical and telecommunications Busbar to ground.

3.05 IDENTIFICATION AND LABELING

A. Label Grounds at point of termination.

B. Label for TBB connection at TMGB and TGB(s) shall be plastic and include the following:

IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL THE BUILDING TELECOMMUNICATIONS MANAGER.

3.06 CONSTRUCTION VERIFICATION

A. Record locations of all electrical and telecommunications grounding electrodes, busbars and grounding conductors as installed including recorded ground resistance test results.

END OF SECTION

SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL
Scope
Related Work
Submittals
Quality Assurance
PART 2 - PRODUCTS
Material
PART 3 - EXECUTION
Installation

1.01 SCOPE

A. The work under this sections includes conduit and equipment supports, straps, clamps, steel channel, etc., and fastening hardware for supporting electrical work. Included are the following topics:

1.02 RELATED WORK

A. Applicable provisions of Division 1 govern work under this Section.
B. Section 26 05 53 – Identification for Electrical Systems

1.03 SUBMITTALS

A. Product Data: Provide data for support channel.

1.04 QUALITY ASSURANCE

A. Support systems shall be adequate for weight of equipment and conduit, including wiring, which they carry.

PART 2 - PRODUCTS

2.01 MATERIAL

A. Support Channel
1. Epoxy Painted:
    a. Strut shall be made from steel meeting the minimum mechanical properties of ASTM A1011 SS Grade 33, then painted with water born epoxy applied by a cathodic electro-deposition process.
    b. All fittings and hardware shall be zinc plated in accordance with ASTM B633 (SC3 for fittings, SC1 for threaded hardware).
2. Hot-dip Galvanized Steel:
    a. Strut shall be made from steel meeting the minimum mechanical properties of ASTM A1011 SS, Grade 33 and shall be hot-dip galvanized after fabrication in accordance with ASTM A123.
    b. Fittings shall be manufactured from steel meeting the minimum requirements of ASTM A907 SS, Grade 33, and hot-dip galvanized after fabrication in accordance with ASTM A123.
    c. All hardware shall be stainless steel Type 304 or chromium zinc ASTM F1136 Gr. 3.
    d. All hot-dip galvanized after fabrication products must be returned to point of manufacture after coating for inspection and removal of all sharp burrs.
3. Stainless Steel:
    a. All strut, fittings and hardware shall be made of AISI Type 304 or Type 316 stainless steel as indicated.
4. Conduit Supports:
    a. Conduit clamps, straps, supports, etc., shall be steel or malleable iron.

B. One-hole straps shall be heavy duty type. All straps shall have steel or malleable backing plates when rigid steel conduit is installed on the interior or exterior surface of any exterior building wall.
C. Above suspended ceilings, bar joist conduit hangers: Spring Steel Clips with Snap-Close Clamps (Conduit Supports): Conduit clamps shall pivot a full 360 degrees and shall snap close around the conduit. Push-in type conduit clamps are not allowed. Spring clips shall require a hammer to install onto supporting surface.

D. Stud wall applications: Spring Steel Clips with Push-in or Snap-Close Conduit Clamps (Conduit Supports): Conduit clamps shall pivot a full 360 degrees. Spring clips shall require a fastener to install onto stud.
E. Box/conduit hanger with rod/wire clip (a.k.a. antlers): One assembly provides support for electrical box and conduit from drop wire or rod. Conduit clamps shall snap close around the conduit.
F. Spring Steel Clip products shall be provided with corrosion resistance and be warranted against failure from corrosion for a period of ten (10) years from date of manufacture.
G. Threaded Rod: Minimum sized threaded rod for supports shall be 3/8" for trapezes and single conduits 1-1/4" and larger, and ¼" for single conduits 1" and smaller.
H. Hardware: Corrosion resistant, or as noted for each product above.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Fasten hanger rods, conduit clamps, and outlet-, junction-, and pull-boxes to building structure using pre-cast insert system, preset inserts, beam clamps, or expansion anchors.
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 anchors on concrete surfaces; sheet metal screws in sheet metal studs and wood screws in wood construction. If nail-in anchors are used, they must be removable type anchors.
C. Powder-actuated fasteners are not permitted.
D. Do not fasten supports to piping, ductwork, mechanical equipment, cable tray or conduit. Do not fasten to suspended ceiling grid system.
E. In wet locations, mechanical rooms, and electrical rooms, install free-standing electrical equipment on 3.5-inch (89 mm) concrete pads.
F. Install surface-mounted cabinets and panelboards with a minimum of four anchors. At all cabinet and panelboard locations on concrete or concrete block walls, and at ALL locations below grade, provide steel channel supports to stand cabinet one inch (25 mm) off wall (7/8" Uni-strut or 3/4" painted fire-retardant plywood is acceptable). In above-grade equipment rooms that have drywall walls, the cabinets and panelboards may be mounted to the drywall if backing is provided in the stud walls behind the equipment.
G. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.
H. Furnish and install all supports as required to fasten all electrical components required for the project, including free standing supports required for those items remotely mounted from the building structure, catwalks, walkways etc.
I. Fabricate supports from galvanized 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.
J. Support Channel. Use one of the following types of support channel as appropriate for the installed environment:
    1. Indoor: Epoxy Painted Steel, Hot-dipped Galvanized Steel, or as noted on the drawings.
    2. Exterior and wet locations: Hot-dipped Galvanized Steel or Stainless Steel, as appropriate for the environment or as noted on the drawings. Type 316 stainless steel shall be used for Food Service type environments. Epoxy painted support channel shall not be used for exterior installations.
K. Manholes, steam pits, steam tunnels, or corrosive environments: Stainless Steel Type 316.
L. Field cuts: File and de-bur cut ends of support channel and paint to prevent rusting. For epoxy-painted support channel, paint cut ends to match the original color. For hot-dipped galvanized support channel, spray cut ends with cold galvanized paint.
M. Support Wires:
    1. Support wires that are installed in addition to the ceiling grid support wires to provide secure support for raceways, cables assemblies, boxes, cabinets, and fittings shall be secured at both ends (e.g. the ceiling structure at the top and the ceiling grid at the bottom) per NEC 300.11(A).
N. Compressed-air power-actuated fasteners may ONLY be used for the installation of separate ceiling wires required for support of conduits and aircraft cable hung light fixtures.
O. Support wires shall be identified per specification section 26 05 53.
P. Spring Steel Clip Conduit Supports
    1. Above suspended ceilings: Spring steel clips with snap-close clamps may be used to support conduit from bar joist (steel truss) systems above suspended ceilings.

2. Stud wall applications: Spring steel clips with push-in or snap-close conduit clamps may be used to support conduit in interior metal stud wall applications. Use screw fasteners to install conduit clamp onto stud.

END OF SECTION

SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

PART 1 - GENERAL
Scope
Related Work
References
Submittals
PART 2 - PRODUCTS
General
Rigid Metal Conduit (RMC) and Fittings
Intermediate Metal Conduit (IMC) and Fittings
Electrical Metallic Tubing (EMT) and Fittings
Flexible Metal Conduit (FMC) and Fittings
Conduit Supports
Conduit Water Sealant
Pull and Junction Boxes
Outlet Boxes
Outlet Box Extenders
Boxes for Fire Alarm Duct Detector and associated accessories.
PART 3 - EXECUTION
Conduit Sizing, Arrangement, and Support
Conduit Installation
Conduit Installation Schedule
Coordination of Box Locations
Pull and Junction Box Installation
Outlet Box Installation
Construction Verification Items

1.01 SCOPE

A. This section describes the products and execution requirements relating to furnishing and installing raceways and boxes and related systems as part of a raceway system for electrical, communications, and other low-voltage systems for the project.

1.02 RELATED WORK

A. Applicable provisions of Division 1 govern work under this section.
B. Section 26 05 26 – Grounding and Bonding for Electrical Systems
C. Section 26 05 29 – Hangers and Supports for Electrical Systems.
D. Section 26 27 02 – Equipment Wiring Systems.
E. Section 26 27 26 – Wiring Devices.

1.03 REFERENCES

A. Wisconsin Administrative Code SPS 316 - Electrical
B. ANSI/TIA-569-C-Telecommunications Pathways and Spaces

1.04 SUBMITTALS

A. Surface Raceway System - submit product data and catalog sheets for all components.
B. Boxes - provide product data showing configurations, finishes, dimensions, and manufacturer's instructions.
C. Conduits in Concrete Slabs Above Grade - provide proposed conduit routing and sizing to Structural Engineer prior to approval of installation to verify structural integrity and fire rating of concrete slab.

PART 2 - PRODUCTS

2.01 GENERAL

A. All steel fittings and conduit bodies shall be galvanized.
B. All conduit transitional fittings shall be listed for installed application.
C. No cast metal or split-gland type fittings permitted.

D. Mogul-type conduits larger than 2 inch (50 mm) not permitted except as approved or detailed.
E. All conduit covers must be fastened to the conduit body with screws and be of the same manufacture.
F. C-conduits shall not be used in lieu of pull boxes.
G. All boxes shall be of sufficient size to provide free space for all conductors enclosed in the box and shall comply with NEC requirements.

2.02 RIGID METAL CONDUIT (RMC) AND FITTINGS

A. Conduit: Heavy wall threaded, galvanized steel, schedule 40.
B. Fittings and Conduit Bodies: Use all steel threaded fittings and conduit bodies.
C. Expansion Fittings/Expansion Joints: Expansion Fittings shall be Internal Grounding type and shall not rely on external bonding jumpers to maintain grounding continuity between raceway components.

2.03 INTERMEDIATE METAL CONDUIT (IMC) AND FITTINGS

A. Conduit: Galvanized steel or aluminum, threaded.
B. Fittings and Conduit Bodies: Use all steel or aluminum threaded fittings and conduit bodies.
C. Expansion Fittings/Expansion Joints: Expansion Fittings shall be Internal Grounding type and shall not rely on external bonding jumpers to maintain grounding continuity between raceway components.

2.04 ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS

A. Conduit: Steel, Unthreaded thin wall galvanized tubing.
B. Fittings: All steel, compression or set screw type. No push-on or indenter types permitted.
C. Conduit Bodies: All steel conduit bodies.

2.05 FLEXIBLE METAL CONDUIT (FMC) AND FITTINGS

A. Conduit: steel, galvanized, spiral strip.
B. Fittings and Conduit Bodies: All steel, galvanized or malleable iron (except as allowed in specification 26 51 13).

2.06 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC) AND FITTINGS

A. Conduit: flexible, steel, galvanized, spiral strip with an outer Liquid tight, nonmetallic, sunlight-resistant jacket.
B. Fittings and Conduit Bodies: ANSI/NEMA FB 1, compression type. There shall be a metallic cover/insert on the end of the conduit inside the connector housing to seal the cut conduit end.

2.07 CONDUIT SUPPORTS

A. See section 26 05 29.

2.08 CONDUIT WATER SEALANT

A. Description: Conduit sealant used to prevent water from entering buildings via conduits.
B. Sealant shall seal conduits against water and gas intrusion, such as Polywater® FST™-250 Foam Duct Sealant, Raychem RDSS Rayflate Duct Sealing System, or approved alternate. Sealant shall be re-enterable, shall be compatible with the conduit and conductor types being used, and shall comply with NEC 225.27, 230.8, and 300.5(G).
C. Manufacturer names and catalog numbers are used to develop quality and performance requirements only. Products manufactured by others may be acceptable provided they meet or exceed the specifications.

2.09 PULL AND JUNCTION BOXES

A. Interior Sheet Metal Boxes: code gauge galvanized steel, screw covers, flanged and spot-welded joints and corners.
B. Interior Sheet Metal Boxes larger than 12 inches (300 mm) in any dimension shall have a hinged cover or a chain installed between box and cover. Boxes 9 square-feet or larger shall have hinged covers and a single cover shall not exceed 10 square-feet.
C. Interior Sheet Metal Boxes connected to an exterior underground raceway, shall have a drain fitting located in the bottom.
D. Exterior Boxes and Wet Location Installations: Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as rain-tight. [Galvanized cast iron][Aluminum][PVC] box and cover with ground flange, neoprene gasket, and stainless steel cover screws.
E. Box extensions and adjacent boxes within 48 inches of each other are not allowed for the purpose of creating more wire capacity.

F. Junction boxes 6 inch-by-6 inch or larger size shall be without stamped knock-outs.
G. Wireways shall not be used in lieu of junction boxes.

2.10 OUTLET BOXES

A. Sheet Metal Outlet Boxes: galvanized steel, with stamped knockouts.
B. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include 3/8 inch male fixture studs where required.
C. Concrete Ceiling Boxes: Concrete type.
D. Cast Boxes: Cast ferroalloy or aluminum, deep type, gasketed cover, threaded hubs.

2.11 OUTLET BOX EXTENDERS

A. Outlet Box Extenders: Non-Metallic, adjustable depth.
B. Outlet Box Extenders may only be used in limited applications with the pre-approval of Dane County. See Part 3 – Execution for examples of applications of where Outlet Box Extenders may be allowed.

2.12 BOXES FOR FIRE ALARM DETECTION AND ASSOCIATED

A. Recessed boxes for Fire Alarm audio, visual, and audio-visual notification appliances shall be galvanized steel sheet metal with stamped knockouts. Boxes shall be painted red.
B. For surface mounting, use manufacturer supplied back boxes and trim plates, painted red or off white to match device color, and shall contain no visible conduit knock-outs. Mark each device with its circuit number.

PART 3 - EXECUTION

3.01 CONDUIT SIZING, ARRANGEMENT, AND SUPPORT

A. EMT is permitted to be used in sizes 4 inch (100 mm) and smaller for power and low-voltage systems. See CONDUIT INSTALLATION SCHEDULE below for other limitations for EMT and other types of conduit.
B. Size power conductor raceways for conductor type installed. Conduit size shall be 1/2 inch (16 mm) minimum except **all homerun conduits shall be 3/4 inch (21 mm),** or as specified elsewhere. **Caution: Per the NEC, the allowable conductor ampacity is reduced when more than three current-carrying conductors are installed in a raceway. Contractor must take the NEC ampacity adjustment factors into account when sizing the raceway and wiring system.**
C. Size communications and other low-voltage systems raceways as follows:
    1. Control, security, signal, video, and other low-voltage applications: 3/4 inch minimum.
    2. Fire Alarm: 1/2 inch minimum.
D. Arrange conduit to maintain 6’-8” clear headroom and present a neat appearance.
E. Route exposed conduit and conduit above accessible ceilings parallel and perpendicular to walls and adjacent piping.
F. Maintain minimum 6 inch (150 mm) clearance between conduit and piping. Maintain 12 inch (300 mm) clearance between conduit and heat sources such as flues, steam pipes, and heating appliances.
G. Arrange conduit supports to prevent distortion of alignment by wire pulling operations. Fasten conduit using galvanized pipe straps, conduit racks (lay-in adjustable hangers), clevis hangers, or bolted split stamped galvanized hangers.
H. Group conduit in parallel runs where practical and use conduit rack (lay-in adjustable hangers) constructed of steel channel with conduit straps or clamps. Provide space for 25 percent additional conduit.
I. Do not fasten conduit with wire or perforated pipe straps. Before conductors are pulled, remove all wire used for temporary conduit support during construction.
J. Support and fasten metal conduit at a maximum of 8 feet (2.4 m) on center.
K. Supports shall be independent of the installations of other trades, e.g. ceiling support wires, HVAC pipes, other conduits, etc., unless so approved or detailed.
L. Conceal all conduits except where noted on the drawings or approved by the Architect/Engineer. Contractor shall verify with Architect/Engineer all surface conduit installations except in mechanical rooms.
M. Changes in direction shall be made with symmetrical bends, cast steel boxes, stamped metal boxes or cast steel conduit bodies.
N. For indoor conduits, no continuous conduit run shall exceed 100 feet (30 meters) without a junction box.
O. All conduits installed in exposed areas shall be installed with a box offset before entering box.

3.02 CONDUIT INSTALLATION

A. Cut conduit square; de-burr cut ends.
B. Conduit shall not be fastened to the corrugated metal roof deck.
C. Bring conduit to the shoulder of fittings and couplings and fasten securely.
D. Use conduit hubs for fastening conduit to cast boxes. Use sealing locknuts or conduit hubs for fastening conduit to sheet metal boxes in damp or wet locations.
E. Threads to be coated with approved electrically conductive corrosion compound per NEC 300.6. Coating to be listed for installed environment, i.e. food service.
F. Terminate all conduit (except for terminations into conduit bodies) using conduit hubs, or connectors with one locknut, or utilize double locknuts (one each side of box wall).
G. Provide bushings for the ends of all conduit not terminated in box walls. Refer to Section 26 05 26 – Grounding and Bonding for Electrical Systems for grounding bushing requirements.
H. Provide insulated bushings where raceways contain 4 AWG or larger conductors.
I. Communication and Low Voltage systems conduits shall terminate in horizontal plane.
J. Install no more than the equivalent of:
    1. Three 90 degree bends between boxes for electrical systems.
    2. Two 90 degree bends between boxes for communications and other low voltage systems. Note: Offsets shall be considered 90 degrees.
    3. No single bend may exceed 90 degrees.
K. Use hydraulic one-shot conduit bender or factory elbows for bends in conduit larger than 2 inch (50 mm) size unless sweep elbows are required.
L. Bend conduit according to manufacturer's recommendations. Torches or open flame shall not be used to aid in bending of PVC conduit.
M. Use suitable conduit caps or other approved seals to protect installed conduit against entrance of dirt and moisture.
N. Provide 1/8 inch (3 mm) nylon pull string in empty conduit, except sleeves and nipples.
O. Install listed expansion-deflection fitting or other approved means shall be used where a raceway crosses a structural joint for expansion, contraction or deflection, used in buildings, bridges, parking garages or other structurers.
P. Install expansion joints where direct-buried conduit is subject to Earth Movement by settlement or frost per NEC 300.5(J), especially where conduit exits the ground exposed and enters a box, cabinet, or enclosure attached to a building or structure.
Q. Install expansion fitting in exterior PVC conduit runs per NEC table 352.44 utilizing a minimum temperature change of 120 degree F.
R. Avoid moisture traps where possible. Where moisture traps are unavoidable, provide junction boxes with drain fittings at conduit low points.
S. Where conduit passes between areas of differing temperatures such as into or out of cool rooms, freezers, unheated and heated spaces, buildings, etc., provide conduit or box with duct seal or other means to prevent the passage of moisture and water vapor through the conduit.
T. Route conduit through roof openings for piping and ductwork where possible.
U. Where communication cabling is to be installed in conduit to the wiring hub (e.g. Telecom Room), multiple conduits may be consolidated into fewer, larger conduits. Capacity of shared conduits shall equal the capacity of the individual conduits unless otherwise noted.
V. Use NRTL listed metallic grounding clamps when terminating conduit to cable tray.
W. Ground and bond conduit under provisions of Section 26 05 26.
X. Conduit is not permitted in any slab topping of two inches (50 mm) or less.
Y. Maximum Size Conduit in Concrete Slabs Above Grade: 1 inch (25 mm). Do not route conduits to cross each other in slabs above grade. Minimum conduit spacing shall be 6 inches on center.
Z. Identify conduit under provisions of Section 26 05 53.
AA. All conduit installed underground (exterior to building) shall be buried a minimum of 24 inches below finished grade, whether or not the conduit is concrete encased. Install warning tape 12" below finish grade over all buried conduits. Underground warning tape shall be detectable, 2" wide minimum, 5 mil thickness, containing a foil core. Tape color shall be red and labeled with the words "CAUTION-BURIED ELECTRIC LINE BELOW" as manufactured by Presco or similar.
BB. Conduits penetrating underground foundation walls: Individual conduits or each conduit as part of a ductbank penetrating underground foundation walls (excluding manholes) shall be sealed against water intrusion into the building.

3.03 CONDUIT INSTALLATION SCHEDULE

A. Conduit other than that specified below for specific applications shall not be used.

B. Underground Installations That Do Not Penetrate Foundation Walls: Rigid metal conduit.
C. Underground Installations Emerging from Grade: Buried conduit emerging from grade shall be Rigid metal conduit extending from the minimum cover distance of 24 inches below grade to the conduit termination point above grade.
D. Concrete Duct Bank: Rigid Metal Conduit
E. Emerging from Concrete Duct Bank: Rigid Metal conduit.
F. Exposed Outdoor Locations: Rigid Metal conduit, Intermediate Metal conduit.
G. Wet Interior Locations: Exposed: Rigid metal conduit
H. Concealed Dry Interior Locations: Electrical metallic tubing.
I. Exposed Dry Interior Locations: Rigid metal conduit, Intermediate metal conduit, Electrical metallic tubing.
J. Motor and equipment connections: Liquidtight flexible metal conduit (LFMC) in all locations except in Mechanical equipment plenum spaces where Flexible Metal Conduit (FMC) shall be utilized. Minimum length shall be one foot (300 mm); maximum length shall be three feet (900 mm). Conduit must be installed perpendicular to direction of equipment vibration to allow conduit to freely flex.
K. Exposed Dry Interior Locations for HVAC control devices with Conduit Connections: Electrical metallic tubing, Flexible Metal Conduit (FMC). For FMC installations, Minimum length shall be one foot (300 mm), Maximum length shall be three feet (900 mm). Minimum size FMC of 3/8".
L. Exposed Dry Interior Locations for HVAC control devices without Conduit Connections: Where HVAC equipment control panels or devices do not provide for the direct connection of conduits, exposed Class 2 wiring may be extended to complete the final connections in dry locations, provided it does not exceed 18 inches in length.
M. Plenum Spaces: Installation shall comply with requirements of NEC 300.22.

3.04 COORDINATION OF BOX LOCATIONS

A. Provide electrical boxes as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.
B. Electrical box locations shown on Contract Drawings are approximate unless dimensioned. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.
C. No outlet, junction, or pull boxes shall be located where it will be obstructed by other equipment, piping, lockers, benches, counters, etc.
D. Conduit and boxes shall not be fastened to the metal roof deck. If conduit and boxes are required to be located and installed on roof decks, the conduit and boxes are required to be spaced minimum 1-5/8 inch off the lowest part of the metal roof decking material, per NEC 300.4 (E).
E. It shall be the Contractor's responsibility to study drawings pertaining to other trades, to discuss location of outlets with workmen installing other piping and equipment and to fit all electrical outlets to job conditions.
F. In case of any question or argument over the location of an outlet, the Contractor shall refer the matter to the Architect/Engineer and install outlet as instructed by the Architect/Engineer.
G. The proper location of each outlet is considered a part of this contract and no additional compensation will be paid to the Contractor for moving outlets which were improperly located.
H. Locate and install boxes to allow access to them. Where installation is inaccessible, coordinate locations and provide 18 inch (450 mm) by 24 inch (600 mm) access doors. Boxes must be installed within 12" from edge of the access door.
I. Locate and install to maintain headroom and to present a neat appearance.
J. Install boxes to preserve fire resistance rating of partitions and other elements, using approved materials and methods.
K. Boxes installed in the building envelop shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and locations per IEC 502.4.3.

3.05 PULL AND JUNCTION BOX INSTALLATION

A. Pull boxes and junction boxes shall be provided in compliance with NEC.
B. Where used with raceway(s) containing conductors of 4 AWG or larger, pull box shall be sized as required unless otherwise noted on the drawings.
C. Where used with raceway(s) containing conductors on systems over 600V, size pull box per NEC 314 Part IV unless otherwise noted as larger on the drawings.
    1. Size pull boxes for communications per ANSI/TIA-568-C
D. Locate pull boxes and junction boxes above accessible ceilings, in unfinished areas or furnish and install approved access panels in non-accessible ceilings where boxes are installed. All boxes are to be readily-accessible.

E. Provide Pull and Junction boxes for communications and other low voltage applications (a) in any section of conduit longer than 100 feet, (b) where there are bends totaling more than 180 degrees between pull points or pull boxes and (c) wherever there is a reverse bend in run. Locate boxes on straight section of raceway (e.g. do not use boxes in place of raceway bends).
F. Support pull and junction boxes independent of conduit.

3.06 OUTLET BOX INSTALLATION

A. Do not install boxes back-to-back in walls. Provide minimum 6 inch (150 mm) separation, except provide minimum 24 inch (600 mm) separation in acoustic-rated walls.
B. Power:
    1. Recessed (1/4 inch maximum) outlet boxes in masonry, concrete, tile construction, or drywall shall be minimum 4 inch square, with device rings. Device covers shall be square-cut except rounded corner plaster rings are allowed in drywall applications. Angle cut plaster rings are not permitted. Coordinate masonry cutting to achieve neat openings for boxes. A single gang box can be used in drywall and masonry, for a single device location, when a single conduit enters box.

    2. Shallow 4 inch square by 1 1/2 inch deep boxes can be used as device boxes for power provided the box and plaster ring is sized for installed device and conductors.
C. Low Voltage:

    1. Recessed (1/4 inch maximum) outlet boxes in masonry, concrete, tile construction or drywall shall be minimum 4 11/16 inch square by 2 1/8 inch deep with single gang device ring (unless noted otherwise on drawings). Device covers shall be square-cut except rounded corner plaster rings are allowed in drywall applications. Angle cut plaster rings are not permitted. Coordinate masonry cutting to achieve neat openings for boxes.

    2. Provide one conduit from each communications outlet box. Conduit runs between outlet boxes for communications are not allowed. Terminate conduit [above accessible ceiling] [above accessible ceiling in corridor] [on cable tray] [as detailed on drawings].
D. Provide knockout closures for unused openings.
E. Support boxes independently of conduit except for cast boxes that are connected to two rigid metal conduits, both supported within 12 inches (300 mm) of box.
F. Install boxes in walls without damaging wall insulation.
G. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.
H. Ceiling outlets shall be 4 inch square, minimum 2 1/8 inch (54 mm) deep except that concrete boxes and plates will be approved where applicable. Position outlets to locate luminaires as shown on reflected ceiling plans.
I. In inaccessible ceiling areas, position outlets and junction boxes within 6 inches (150 mm) of recessed luminaire, to be accessible through luminaire ceiling opening.
J. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioning 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.
K. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.
L. Provide cast ferroalloy or aluminum outlet boxes in exterior and wet locations.
M. Surface wall outlets shall be 4 inch (100 mm) square with raised covers for one and two gang requirements. For three gang or larger requirements, use gang boxes with non-overlapping covers.

END OF SECTION

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL
Scope
Related Work
Submittals
PART 2 - PRODUCTS
Materials
PART 3 - EXECUTION
General
Box Identification
Communication Conduit Labeling
Power, Control and Signal Wire Identification
Wiring Device Identification
Support Wire Identification
Nameplate Engraving for Electrical Equipment
Panelboard Directories

1.01 SCOPE

A. The work under this section includes the products and execution requirements relating to labeling of power, control, signaling and fire alarm wiring. Further, this section includes the installation of labels, nameplates, and directories for electrical boxes, wiring devices, and equipment.

1.02 RELATED WORK

A. Applicable provisions of Division 1 shall govern work under this section.
B. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
C. Section 26 05 23 – Control-Voltage Electrical Power Cables

1.03 SUBMITTALS

A. Include schedule for nameplates.
B. Prior to installation, the Contractor shall provide samples of all label types planned for the project. These samples shall include examples of the lettering to be used. Samples shall be mounted on 8 1/2" x 11" sheets annotated, explaining their purposed use.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Labels: All labels shall be permanent, and machine generated. NO HANDWRITTEN OR NON-PERMANENT LABELS ARE ALLOWED.
B. Wire Labels: All wiring labels shall be white/transparent vinyl or vinyl-cloth, self-laminating, wraparound type. Flag type labels are not allowed. The labels shall be of adequate size to accommodate the circumference of the cable being labeled and properly self-laminate over the full extent of the printed area of the label.
C. Tape (wiring phase identification only): Scotch #35 tape in appropriate colors for system voltage and phase.
D. Nameplates: Engraved three-layer laminated plastic. Normal system shall use nameplates with black letters on white background, emergency system (NEC 700) shall use white letters on red background, legally required standby system (NEC 701) shall use white letters on blue background, and optional standby system (NEC 702) shall use black letters on yellow background.
E. See Box Identification and Wiring Device Identification sections for allowed usage of permanent marker.

PART 3 - EXECUTION

3.01 GENERAL

A. All branch circuit and power panels shall be identified with the same symbol used in circuit directory in main distribution center.

B. Clean all surfaces before attaching labels with the label manufacturer's recommended cleaning agent. Install all labels firmly as recommended by the label manufacturer. Labels shall be installed plumb and neatly on all equipment.

C. Install nameplates parallel to equipment lines. Secure nameplates to equipment fronts using screws, rivets or manufacturer approved adhesive or cement.
D. Embossed tape shall not be permitted for any application.
E. Provide all warning labels to electrical equipment as required per NEC 110.16 and 110.21. Provide available fault current labeling to service equipment as required per NEC 110.24.
F. Provide a sign at the service-entrance equipment indicating type and location of on-site emergency power sources and on-site legally required standby power sources, per NEC 700.7 and NEC 701.7.
G. Provide a sign at each service disconnect indicating "Service Disconnect", per NEC 230.70(B).

3.02 BOX IDENTIFICATION

A. The following junction and pull boxes shall be identified utilizing spray painted covers:

1. System	Color(s)
Secondary Power – 208Y/120V, 240/120V	White
Emergency System (NEC 700) – 208Y/120V	White/Red
Legally Required Standby System (NEC 701) – 208Y/120V	White/Blue
Fire Alarm (see below)	Red
Temperature Control	Green
Communications	Blue

B. All boxes with power wiring shall be further identified with circuit numbers and source panel designation as follows:
   1. All outlet and device boxes shall use machine-generated adhesive labels, or neatly hand-written permanent marker.
   2. All exposed junction and pull boxes larger than 8" square shall utilize engraved nameplates with ½" minimum letter height. All exposed junction and pull boxes 8" square or smaller shall utilize machine-generated adhesive labels.
   3. All junction and pull boxes located above an accessible ceiling shall utilize machine-generated adhesive labels, or neatly hand-written permanent marker.
   4. All fire alarm boxes (covers and outer sides) shall be painted red and labeled "Fire Alarm" or "FA". When red conduit is used for the alarm system installation, there is no need to paint the box sides, - paint the covers only. Non-factory device boxes shall also be painted red.
   5. Other system boxes shall be further identified as shown on drawing details or approved shop drawings.

3.03 COMMUNICATIONS CONDUIT LABELING

A. Provide label on all conduits installed between Telecommunication Equipment Rooms. Both ends of the conduits shall be labeled. All labels shall be mechanical, no hand-written labels.

B. The label shall indicate the location of the far end of the conduit run and a unique conduit number. (i.e. TR-1A-01 or Room #216 – 01). Refer to agency standards where applicable.

3.04 POWER, CONTROL AND SIGNALING WIRE IDENTIFICATION

A. Provide wire labels on each conductor in panelboard gutters, all boxes, and at load connection. Identify with branch circuit or feeder number for power and lighting circuits, and with wire number as indicated on schematic and interconnection diagrams or equipment manufacturer's shop drawings for control and signaling wires.

B. All wiring shall be labeled within 2 to 4 inches of terminations. Each end of a wire or cable shall be labeled as soon as it is terminated, including wiring used for temporary purposes.

3.05 WIRING DEVICE IDENTIFICATION

A. Wall switches, receptacles, occupancy sensors, photocells, poke-through fittings, access floor boxes, and time clocks shall be identified with circuit numbers and source (ex. Panel ABC-3). In exposed areas, identifications should be made inside of device covers, unless directed otherwise. Use machine-generated adhesive labels, or neatly hand-written permanent marker.

3.06 SUPPORT WIRE IDENTIFICATION

A. Support wires that are installed in addition to the ceiling grid support wires to provide secure support for raceways, cables assemblies, boxes, cabinets, and fittings shall be distinguishable from the ceiling grid support wires per NEC 300.11(A). This identification shall be either approximately 6 inches of fluorescent orange paint, or orange tape flags 3/4 inches high-by-2 inches wide (minimum) within 12 inches of the bottom of the support wires.

3.07 NAMEPLATE ENGRAVING FOR ELECTRICAL EQUIPMENT

A. Provide nameplates of minimum letter height as scheduled below.
B. All Panelboards (Distribution, Branch, Sub-feed, and Feed-Through), identify equipment designation. 1/2 inch (13 mm); identify voltage rating, source and room location of the source. Panelboards serving NEC 700, 701 or 702 loads shall identify which branch they serve. Both panels in a double tub application shall be labeled.
C. Provide short circuit and arc flash ratings in compliance with the NEC and state requirements.
D. Circuit Breakers, Switches, and Motor Starters in Distribution Panelboards, Switchboards and Motor Control Centers: 1/2 inch (13 mm); identify circuit number and load served, including location.
E. Individual Circuit Breakers, Disconnect Switches, Enclosed Switches, and Motor Starters: ½ inch (13 mm); identify source and load served.

3.08 PANELBOARD DIRECTORIES

A. Typed directories for panelboards shall be covered with clear plastic and have a metal frame. Room number on directories shall be Owner's numbers, not Plan numbers unless Owner so specifies.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 – GENERAL

1.01 SCOPE OF WORK
A. Base Bid: The work under this section includes main, distribution and branch circuit panelboards.

1.02 SECTION INCLUDES
A. Power Distribution Panelboards
B. Branch Circuit Panelboards
C. Coordination Branch Panelboards
D. Coordination of Overcurrent Protective Devices

1.03 RELATED WORK
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.
B. Section 26 27 13 – Electricity Metering
C. Section 26 43 13 – Surge Protective Devices for Low Voltage Electrical Power Circuits

1.04 SUBMITTALS
A. Include outline and support point dimensions, voltage, main bus ampacity, circuit breaker arrangement and sizes, and interrupting ratings confirming a fully-rated system for all equipment and components.

1.05 OPERATION AND MAINTENANCE DATA
A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

1.06 SPARE PARTS
A. Keys: Furnish 2 keys for each panelboard to Owner.
B. Handle lock-off: Furnish (2) 20/1P circuit breaker handle lock-off devices for each panelboard to Owner.

PART 2 – PRODUCTS

2.01 POWER DISTRIBUTION PANELBOARDS
A. Panelboards: Circuit breaker type. The panelboard and overcurrent devices contained within shall be **fully-rated.**

Enclosure: NEMA Type 1.[Minimum cabinet size: 6.5 inches (165 mm) deep; 26 inches (660 mm) wide. Constructed of galvanized code gauge steel.

Power distribution panelboards shall utilize a standard dead front cover. Provide cabinet front with hinged door, flush lock and hinged trim (door-in-door) to allow access to wiring gutters without removal of panel front. Hinged trim shall be held in place with screw fasteners. Finish in manufacturer's standard gray enamel.

Provide metal directory holders with clear plastic covers. Holder to be factory mounted.

Provide panelboards with copper bus (phase buses, bus fingers, etc.), ratings as scheduled on Drawings. Provide ground bars in all panelboards. Neutral and ground bars can be dual rated ALCU9. All spaces shall have bus fully extended and drilled for the future installation of breakers.

Minimum System (i.e. individual component) Short Circuit Rating: As shown on the Drawings and as required by short circuit/coordination study.

Main breakers shall be individually mounted. Back feed mains shall NOT be utilized.

The circuit breakers are to be totally front accessible and mounted in the panelboard to permit installation, maintenance and testing without reaching over line side bussing. The circuit breakers are to be removable by the disconnection of only the load side terminations and line and load side connections are to be individual to each circuit breaker. Common mounting brackets or electrical bus connectors are not acceptable.

Circuit breakers shall be provided with provisions for mounting handle padlock attachments.

Breaker feeder lugs shall be dual rated for use with either aluminum or copper conductors.

Each circuit breaker is to be furnished with an externally operable mechanical means to trip the circuit breaker, enabling maintenance personnel to verify the ability of the circuit breaker trip mechanism to operate, as well as exercise the circuit breaker operating mechanisms.

A minimum of 20% future circuit breaker spaces shall be included. Spaces for future circuit breakers shall be "prepared" spaces. These spaces shall be provided with the necessary mounting hardware and bus extensions so that when future breakers are added, only the breaker itself needs to be purchased by the installer.

Circuit breakers serving single motor loads shall be magnetic only, instantaneous trip. Overload protection shall be part of the motor combination controller.

Surge Protective Device: Provide a surge protective device meeting the requirements of specification section 26 43 13

Circuit Breakers:

A. Electronic Trip Circuit Breakers: As scheduled on the drawings, electronic circuit breakers shall have, at a minimum, adjustments for long time, short time and instantaneous trip. Provide integral ground fault sensing with adjustable ground fault trip where indicated on the drawings.

B. Molded Case Circuit Breakers: As scheduled on the drawings, integral thermal and instantaneous magnetic trip elements in each pole.

2.02 BRANCH CIRCUIT PANELBOARDS:

A. .Fire Rating: 3 hours.

2.03 COORDINATION OF OVERCURRENT PROTECTIVE DEVICES

A. Provide a coordination study of the electrical system and recommend set points for all of the overcurrent and ground fault trip adjustments on the equipment provided. The coordination study and set point recommendations shall be submitted to the consulting engineer for approval. Submittal shall be on or before date of switchboard and panelboard equipment submittal.

PART 3 – EXECUTION

3.01 INSTALLATION

See section 26 05 29 for support requirements.
Install panelboards plumb with wall finishes.
Height:

Power Distribution panelboards: Minimum 12" above finished floor and maximum of 6'-7" to center of the grip of the operating handle of the top most mounted switch or circuit breaker, when at its highest position.

Branch panelboards: 6'-0" to top of panelboard.

Install a crimp type stud termination to stranded conductor when terminating on circuit breakers without a captive assembly rated for terminating stranded conductors. Provide filler plates for unused spaces in panelboards. See section 26 05 53 for identification requirements. Provide typed circuit directory for each panelboard per NEC 408.4(A). Revise directory to reflect circuiting changes required to balance phase loads.

Stub three (3) empty ¾" conduits to accessible location above ceiling or below floor out of each recessed panelboard. Cap these conduits to prevent material from entering them.

FIELD QUALITY CONTROL

If aluminum conductors' size #1/0 and larger (per Section 26 05 19) are to be used as panelboard feeders, it is the responsibility of the contractor to provide panelboards with adequate wire bending space to accommodate the aluminum conductors and terminators to meet allowable code requirements. The Contractor shall circuit the panelboards as shown on the drawings. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 10 percent, rearrange circuits in the panelboard to balance the phase loads within 10 percent.

Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections.

AGENCY TRAINING

All training provided for agency shall comply with the format, BASIC REQUIREMENTS and submission guidelines specified under Section 01 00 00.

END OF SECTION

SECTION 26 27 02
EQUIPMENT WIRING SYSTEMS

PART 1 – GENERAL

1.01 SCOPE OF WORK
A. Base Bid: The work under this section includes electrical connections to equipment specified under other Divisions and/or Sections, or furnished by Owner, including, but not limited to:
   1. HVAC motors, VFDs, and panels

1.02 SECTION INCLUDES
A. Cords and Caps
B. Other Products

1.03 RELATED WORK
A. Drawings and general provisions of the Contract, including BASIC REQUIREMENTS and Division 01 Specification Sections, apply to this section.
B. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables.
C. Section 26 05 33 – Raceway and Boxes for Electrical Systems.

1.04 SUBMITTALS
A. Product Data: Provide data for cord and wiring devices.

1.05 COORDINATION
A. Coordinate all equipment requirements with the various contractors and the Owner. Review the complete set of drawings and specifications to determine the extent of wiring, starters, devices, etc., required.

PART 2 – PRODUCTS

2.01 CORDS AND CAPS
A. Straight-blade Attachment Plug: NEMA WD 1.
B. Locking-blade Attachment Plug: NEMA WD 5.
C. Attachment Plug Configuration: Match receptacle configuration at outlet provided for equipment.
D. Cord Construction: Oil-resistant thermoset insulated multiconductor flexible cord with identified equipment grounding conductor, suitable for hard usage in damp locations.
E. Cord Size: Suitable for connected load of equipment and rating of branch circuit overcurrent protection.

2.02 OTHER PRODUCTS
A. Refer to related sections for other product requirements.

PART 3 – EXECUTION

3.01 INSPECTION
A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.02 PREPARATION
A. Review equipment submittals prior to installation and electrical rough-in. Verify location, size, and type of connections. Coordinate details of equipment connections with supplier and installer.

3.03 INSTALLATION
A. Use wire and cable with insulation suitable for temperatures encountered in heat-producing equipment.
B. Make conduit connections to equipment using flexible PVC-coated metal conduit.
C. Install pre-finished cord set where connection with attachment plug is indicated or specified, or use attachment plug with suitable strain-relief clamps.
D. Provide suitable strain-relief clamps for cord connections to outlet boxes and equipment connection boxes.

E. Make wiring connections in control panel or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions. Provide interconnecting wiring where indicated.
F. Install disconnect switches, controllers, control stations, and control devices such as limit switches and temperature switches as indicated. Connect with conduit and wiring as indicated.
G. Coolers and Freezers: Cut and seal conduit openings in freezer and cooler walls, floor, and ceilings.

3.04 HVAC CONNECTIONS

A. Provide all power wiring including all circuitry carrying electrical energy from panelboard or other source through starters, variable frequency drives (VFDs), and disconnects to motors or to packaged control panels. Packaged control panels may include disconnects and starters and overcurrent protection. Provide all wiring between packaged control panels and motors.
B. VFD Installations: Install VFD input wiring and output wiring in separate conduit systems. Do not mix VFD input power and output power, or control wiring in a common raceway.
C. Provide 120 volts to each temperature control panel. Coordinate requirements with HVAC/DDC contractors.
D. Unless otherwise specified, all electrical motors and control devices such as aquastats, float and pressure switches, fan powered VAV boxes, switches, electro-pneumatic switches, solenoid valves and damper motors requiring mechanical connections shall be furnished and installed and wired by the Contractor supplying the devices.
E. Each motor terminal box shall be connected with a minimum 12", maximum 36" piece of flexible PVC-coated metal conduit to a fixed junction box. Conduit must be installed perpendicular to direction of equipment vibration to allow conduit to freely flex.
F. Check for proper rotation of each motor.

3.05 EQUIPMENT CONNECTION SCHEDULE

A. As indicated on the drawings.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 – GENERAL

1.01 SCOPE OF WORK
A. Base Bid: The work under this section includes wall switches, receptacles, occupancy sensors, wall dimmers, device plates and box covers, poke-through service fittings, access floor boxes, photo cells and time clocks.

1.02 SECTION INCLUDES
A. Receptacles
B. Device Plates and Box Covers

1.03 RELATED WORK
A. Drawings and general provisions of the Contract, including BASIC REQUIREMENTS and Division 01 Specification Sections, apply to this section.

1.04 SUBMITTALS
A. Provide product data showing model numbers, configurations, finishes, dimensions, and manufacturer's instructions.
B. For occupancy sensor shop drawings, the manufacturer’s actual layout of occupancy sensors and the wiring diagrams shall be provided.
C. Test Reports

1.05 OPERATION AND MAINTENANCE DATA
A. All operations and maintenance data shall comply with the submission and content requirements specified under section BASIC REQUIREMENTS.

PART 2 – PRODUCTS

2.01 RECEPTACLES
A. Duplex Convenience and Straight-blade Receptacles: NEMA Type 5-20R, ivory nylon or high impact resistant face. Receptacles shall be UL498 Listed, comply with NEMA WD1, NEMA WD6 configuration 5-20R and meet Federal Specification WC-596. All duplex receptacles shall be heavy duty Specification Grade, 20 amp rated. All receptacles shall be back and side wired, screw clamp type, suitable for solid or stranded wire up to #10 AWG, with a separate green ground screw. Receptacles shall be Leviton model 5362-S, Hubbell model CR5362, Pass & Seymour model CRB5362, Pass & Seymour model PT5362 with 90º connector, Cooper model 5362, or approved equal.
B. Generally, all receptacles shall be duplex convenience type unless otherwise noted.
C. All receptacles installed in outdoor locations, in garages, within 6 feet of the outside edge of sinks, and in other damp or wet locations shall be GFCI type.
D. GFCI Receptacles: Duplex convenience straight-blade feed through receptacle, Specification Grade, with integral ground fault current interrupter meeting the requirements of UL standard 943 Class A and include indicator light that is lighted when device is tripped. Device shall comply with NEMA WD1, NEMA WD6, and UL standard 498. GFCI receptacles shall be Leviton model 8899, Hubbell model GRF5352, Pass & Seymour model 2095, Cooper model VGF20 or approved equal.
E. All receptacles on emergency circuits shall have a red face.
F. All receptacles designated as isolated ground shall be 20A rated and have an isolated ground triangle imprint on the face of the receptacle.
G. Specific-use Receptacle Configuration: As indicated on drawings.

2.02 DEVICE PLATES AND BOX COVERS
A. Weatherproof Cover Plate: Gasketed metal with hinged device covers.

B. While in Use Cover: UL Listed outdoor die-cast hinged cover with integral lock tab.
C. Surface Cover Plate: Raised galvanized steel.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install specific-use as noted on Contract Drawings.
B. Receptacles shall have a bonding conductor from grounding terminal to the metal conduit system. Self-grounding receptacles using mounting screws as bonding means are not approved.
C. Oversized or extra deep cover plates not acceptable. Repair wall finishes and remount outlet box when standard device plates do not fit flush or do not cover rough wall opening.
D. Coordination with Other Trades:
   1. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   2. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   3. Install wiring devices after all wall preparation, including, painting, is complete.
E. Conductors:
   1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NPFA 70, Article 300, without pigtails.
F. Device Installation:
   1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudg4e covers, until the last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductors tightly clockwise, 2/3 to ¾ of the way around terminal screw.
   6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
   7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   8. Tighten unused terminal screws on the device.
   9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

3.02 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.
B. Operate each wall switch and sensor with circuit energized and verify proper operation.
C. Verify that each receptacle device is energized.
D. Test each receptacle device for proper polarity.
E. Test each GFCI receptacle device for proper operation.
F. The Engineer and Owner’s personnel reserve the right to be present at all tests.

3.03 ADJUSTING

A. Adjust devices and wall plates to be flush and level.
B. Mark all conductors with the panel and circuit number serving the device with a machine generated label, at the device, and on the back of the device cover.

3.04 TESTING

A. Perform tests and inspections and prepare test reports.
   1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.

2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:
1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Test straight blade [convenience outlets in patient-care areas] [hospital-grade convenience outlets] for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

END OF SECTION

SECTION 26 27 28
DISCONNECT SWITCHES

PART 1 - GENERAL

1.01 SCOPE OF WORK
A. Base Bid: The work under this section includes disconnect switches and enclosures.

1.02 SECTION INCLUDES
A. Disconnect Switches

1.03 RELATED WORK
A. Drawings and general provisions of the Contract, including BASIC REQUIREMENTS.

1.04 SUBMITTALS
A. Include outline drawings with dimensions, and equipment ratings for voltage, ampacity, horsepower, and short circuit.

1.05 OPERATION AND MAINTENANCE DATA
A. All operations and maintenance data shall comply with the submission and content requirements specified under section BASIC REQUIREMENTS.

1.06 PROJECT COORDINATION
A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
B. Disconnect switch manufacturer shall be the same manufacturer as switchboards, distribution panelboards, branch circuit panelboards and motor starters.

PART 2 – PRODUCTS

2.01 DISCONNECT SWITCHES
A. Fusible Switch Assemblies (use only when overcurrent protection is required):UL 09 and NEMA KSI, horsepower rated Type HD, 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: designed to accommodate Class R cartridge type fuses.
B. Service Entrance rated switch as noted on the construction documents.
C. nclosure: NEMA Type as indicated on Drawings.
D. Provide manufacturer’s equipment ground kit in all disconnect switches.
E. Provide [one] [two] NO/NC (form C) auxiliary contacts arranged to activate before switchblades open. Provide internally mounted neutral bar where used with 4 wire circuits.
F. Provide UL Listed service rating where required.

PART 3 – EXECUTION

3.01 INSTALLATION
A. Install disconnect switches where indicated on Drawings.
B. Provide identification as specified in Section 26 05 53.

END OF SECTION

SECTION 26 28 13
FUSES

PART 1 – GENERAL

1.01 SCOPE OF WORK
A. Base Bid: The work under this section includes 250-volt fuses.

1.02 SECTION INCLUDES
A. 250 Volt Fuses
B. Spare-Fuse Cabinet

1.03 RELATED WORK
A. Drawings and general provisions of the Contract, BASIC REQUIREMENTS.
B. Section 01 91 13– Commissioning Requirements
C. Section 26 27 28 – Disconnect Switches
D. Section 26 29 00 – Low Voltage Controllers

1.04 SUBMITTALS
A. Provide device dimensions, nameplate nomenclature, and electrical ratings.
B. Submit manufacturer’s product data sheets with installation instructions.

1.05 REGULATORY REQUIREMENTS
A. Listed by Underwriter's Laboratories, Inc., and suitable for specific application.

1.06 COORDINATION
A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit levels.

1.07 EXTRA MATERIALS
A. Provide three (3) spares of each size and type fuse.

PART 2 – PRODUCTS

2.01 250 VOLT FUSES
A. Fuses 600 Amperes and Less: Dual element, time delay, 250-volt, UL Class [RK 1.] [RK 5.] Interrupting Rating: 200,000 rms amperes.

PART 3 – EXECUTION

3.01 INSTALLATION
A. Fuses shall not be installed until equipment is ready to be energized.
B. Install spare fuse storage enclosure in Electrical Room.

END OF SECTION

SECTION 26 29 00
LOW-VOLTAGE CONTROLLERS

PART 1 – GENERAL

1.01 SCOPE OF WORK
A. Base Bid: The work under this section includes manual motor starters, magnetic motor starters, combination magnetic motor starters and motor control centers.

1.02 SECTION INCLUDES
A. Manual Motor Starters
B. Controller Overcurrent Protection and Disconnecting Means

1.03 RELATED WORK
A. Drawings and general provisions of the Contract, BASIC REQUIREMENTS.
B. Section 26 05 29 – Hangers and Supports for Electrical Systems
C. Section 26 27 28 – Disconnect Switches

1.04 SUBMITTALS
A. Indicate on shop drawings, front and side views of motor control center enclosures with overall dimensions. Include conduit entrance locations and requirements; 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.
B. Provide product data on motor starters and combination motor starters, relays, pilot devices, and switching and overcurrent protective devices.

1.05 REFERENCE STANDARDS
A. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
B. ANSI/UL 198E - Class R Fuses.
C. NEMA AB 1 - Molded Case Circuit Breakers.
D. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies.
E. NEMA KS 1 - Enclosed Switches.
F. NEMA PB 1 - Panelboards.
G. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

1.06 OPERATION AND MAINTENANCE DATA
A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

1.07 DELIVERY, STORAGE AND HANDLING
A. 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.
B. 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.

1.08 COORDINATION WITH OTHER TRADES
A. Motors: In general, all electric motors required for this installation will be supplied with equipment, apparatus and/or appliances covered under other sections of the specifications.
B. For the sake of consistency and conformity of manufacturer, design and construction, all motors shall conform to the following description unless otherwise noted or required.
   1. Motors 1/3 HP and smaller shall be wound for operation on single phase, 60 Hz. service unless otherwise noted.
   2. Motors 1/2 HP and above shall be wound for operation on 3 phase, 60 Hz service unless otherwise noted.

3. Refer to drawings in each case in order to verify voltage characteristics required.

C. Equipment:
   1. All building utility motors such as fans, pumps, overhead doors, etc., together with certain "controlling equipment" for same, except motor starters and related apparatus, will be furnished under other sections of the specifications and delivered to the building site unless specifically noted otherwise. The above mentioned "controlling equipment" pertains to electrical thermostats, electro-pneumatic and pneumatic-electric and detection devices, or any other device not purely electrically operating in nature.
   2. The starters for these motors shall be furnished and installed by the Electrical Trade unless noted otherwise. (See Motor Schedule on Drawings.)
   3. The Electrical Trade shall set and connect all specified starting equipment, install all power conduits and wiring and shall furnish and make all connections from starting equipment to motors as required to leave the apparatus in running condition.

D. Wiring Connections:
   1. Furnish branch circuits for all motors to the starting equipment and then to the motors, complete with all control wiring for automatic and remote control where required or noted. Conduits to motors shall terminate in the conduit fittings on the motors, the final connection being made with flexible, PVC-coated metal conduit.
   2. Provide all necessary labor and material to completely connect all electrical motors and controls (where required) in connection with the building utility equipment, including fans, pumps, overhead door operators, etc.
   3. All conduits and wiring required for control work from the holding coil circuit of the starter, including the furnishing and installation of control devices such as auxiliary contacts, control relays, time delay relays, pilot lights, selector switches, alternators, etc., shall be provided and installed by other trades unless otherwise indicated.

E. Power Branch Circuits:
   1. Wire sizes for branch circuits not specifically called for on drawings or in specifications shall be based on 125 percent of the full load current of the motor unless the voltage drop of motor branch circuits exceeds 1-1/2 percent from the distribution panel to the motor; in which case, voltage drop shall govern wire sizes. A power factor of 80 percent shall be used for motors in such calculations.

1.09 PROJECT COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Motor starter manufacturer shall be the same manufacturer as distribution panelboards, branch circuit panelboards, and disconnect switches.

1.10 SPARE PARTS

A. Keys: Furnish two (2) each to Owner.

B. Provide three (3) spares of each size and type fuse used. Provide enclosure for spare fuses.

C. Fuse Pullers: Furnish one fuse puller to Owner.

PART 2 – PRODUCTS

2.01 MANUAL MOTOR STARTERS

A. Manual Motor Starter: NEMA ICS 2; size as shown on Drawings. AC general-purpose Class A manually operated full-voltage controller for induction motors rated in horsepower, with overload protection, red pilot light and toggle operator.

B. Manual Motor Starter: The single-phase motor starter shall consist of a manually operated quick-make toggle mechanism lockable in the “off” position which shall also function as the motor disconnect. The starter shall provide thermal overload protection, run status pilot light and fault pilot light. The starter must include the capability to operate in both manual and automatic control modes. In automatic mode, the starter shall have the capability to integrate with a building automation system by providing terminals for run input, run status output and fault output. All control terminals shall be integrated in the starter. At a

minimum, each single-phase starter shall include an interposing run relay and current sensing status output relay. Single phase motor starter shall be in a surface mount enclosure. Approved manufacturer: Cerus Industrial, model BAS-IP or approved equal.

C. Enclosure: NEMA Type: As indicated on the drawings.
D. Provide manufacturer's equipment ground kit in all starter enclosures.

2.02 CONTROLLER OVERCURRENT PROTECTION AND DISCONNECTING MEANS

A. [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: [Designed to accommodate Class R fuses.]]

PART 3 – EXECUTION

3.01 INSTALLATION

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."
B. Install motor control equipment in accordance with manufacturer's instructions.
C. Select and install heater elements in motor starters to match installed motor characteristics.
D. Select and install fuses in each fusible switch enclosed controller.
E. Install fuses in control circuits if not factory installed.
F. 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.

3.02 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each enclosure with engraved nameplate.
   3. Label each enclosure-mounted control and pilot device.

END OF SECTION

SECTION 26 43 13
SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL
Scope
Related Work
Reference Standards
Quality Assurance
Warranty
Submittals
Operation and Maintenance Data
PART 2 - PRODUCTS
Surge Protective Devices
PART 3 - EXECUTION
Installation
Agency Training

1.01 SCOPE

A. The work under this section includes Surge Protective Devices (SPDs) as indicated on the project drawings and electrical diagrams.

1.02 RELATED WORK

A. Applicable provisions of Division 1 govern work under this Section.

1.03 REFERENCE STANDARDS

A. ANSI/UL 1449, Fourth Edition – Standard for Surge Protective Devices.
B. ANSI/IEEE C62.41.1 Guide on the Surge Environment in Low-Voltage AC Power Circuits.
C. ANSI/IEEE C62.41.2 Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
D. ANSI/IEEE C62.45 Recommended Practice on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits.
E. IEEE C62.62 Standard Test Specification for Surge Protective Devices for Low-Voltage AC Power Circuits.
F. NFPA 70, NEC Article 285

1.04 QUALITY ASSURANCE

A. The manufacturer shall have been in the Surge Protective Device industry for a minimum of 5 years.

1.05 WARRANTY

A. The manufacturer shall provide a minimum 5-year warranty from the date of shipment of the SPD.

1.06 SUBMITTALS

A. Include all SPD data necessary to show device is in compliance with all product specifications. Include product data sheets showing the device performance, dimensions, weight, connections, and mounting requirements, along with installation instructions.

1.07 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

PART 2 - PRODUCTS

2.01 SURGE PROTECTIVE DEVICES

A. The SPD shall be Listed in accordance with UL 1449, Fourth Edition. The product and ratings shall be included in the database of the UL.com web site.
B. The surge protective device (SPD) shall be designated a location Type 1 or Type 2 device intended for installation on the load side of the service equipment overcurrent device, including SPDs located at the branch panel.
C. The SPD shall be connected in parallel with the facility's electrical system.
D. The SPD shall be made up of metal oxide varistors (MOV's), or a combination of MOV's with selenium cells or silicon avalanche diodes, ensuring that all of the performance requirements are met. Gas tubes shall not be used.

E. The entire SPD shall be enclosed in a metal or ABS enclosure, NEMA rated for the location. SPDs at main service equipment shall be mounted outside the Disconnect or panelboard (not integral to or installed within the switchboard or panelboard). SPDs for branch panelboard (2^{nd} tier) locations may be mounted outside of, or integral to, the branch panelboard. SPDs installed internal to the distribution equipment shall be of the same manufacturer as the equipment.
F. The SPD shall have a maximum continuous operating voltage (MCOV) rating not less than 115% of nominal voltage of the system it is protecting.
G. Protection Modes:
    a. The SPD shall have line to neutral (L-N), line to ground (L-G), line to line (L-L) and neutral to ground (N-G) protection modes for three-phase grounded wye configured systems. For a three-phase delta configured system, the device shall have line to line (L-L) and line to ground (L-G) protection modes.
H. Voltage Protection Rating (VPR):
    a. The UL 1449 Voltage Protection Rating (VPR) for the device shall not exceed the following:
        1. 208Y/120 volt applications: 800V L-N, L-G, N-G; 1200V L-L
I. Nominal Discharge Current (In):
    a. The UL 1449 Nominal Discharge Current Rating (In) shall not be less than the following:
        1. 20kA for service entrance, switchboard, and main distribution panel locations
        2. 10kA for branch panelboard (2^{nd} tier) locations
J. Short Circuit Current Rating (SCCR):
    a. The SPD shall have a UL 1449 Short Circuit Current Rating (SCCR) of not less than 200kA.
K. Surge Current Rating:
    a. The single-pulse (8 X 20 microsecond waveform as specified in ANSI/IEEE Standard C62.41) surge current capacity shall not be less than the following:
        1. 100kA per mode (200kA per phase) for service entrance, switchboard, and main distribution panel locations
        2. 50kA per mode (100kA per phase) for branch panelboard (2^{nd} tier) locations
L. Each SPD shall include externally-mounted LED visual status indicators that indicate the on-line status of the unit, for each phase.
M. At service entrance, switchboard, and main distribution panel locations each SPD shall include the following features:
N. audible diagnostic monitoring by way of an audible alarm function
O. one set of NO/NC dry contracts for alarm conditions

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install SPD units in accordance with manufacturer's written instructions, applicable requirements of NEC and NEMA standards, and recognized industry practices.
B. The SPD units shall be installed at the locations shown on the drawings, or as indicated in the one-line diagram. They shall be parallel-connected to and located adjacent to the switchboard or panelboard being protected. Locate as close as practical to the bus, keeping lead length as short as possible (less than 3 feet preferred to ensure optimum performance).
C. SPDs shall be connected through a multi-pole circuit breaker or fused disconnect switch, not into main lugs. Circuit breaker or fused disconnect switch shall be 60A for main service device, 30A for branch panelboard device or as recommended by the manufacturer.
D. Use schedule 40 PVC conduit or metallic conduit between the SPD and the switchboard or panelboard as recommended by the manufacturer. Avoid sharp bends, excess length, and splices in the wires. Where possible, use a close-nippled connection with wires going directly to a circuit breaker within the switchboard or panelboard.
E. Setup and test per the manufacturer's recommendations.

3.02 AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 00 00 BASIC REQUIREMENTS.

END OF SECTION