DIVISION – ANR PIPELINE COMPANY STANDARDS AND SPECIFICATIONS

TED-1930-VEL Natural Gas Velocity Limits Through Measurement and Pipeline Facilities (US-MEX)

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Approvals

Originator: Alan Anderson, P.L. (Eng) Design Engineering Support	Alan Anderson Signature	May 2-2013 Date
Discipline Checker One: Gerard Lalonde, P. Eng. Design Engineering Support	Signature	May/4/13 Date
Responsible Engineer/Approver Landy Ramirez, P. Eng. Design Engineering Support	Landy Ramirez Signature	5-13-2013 Date
Management Endorsement: Pat Jackson, Manager Design Engineering Support	Signature	May 14, 2013 Date

SUMMARY

This document provides velocity criteria for the design of pipeline and measurement facilities.

DOCUMENT HISTORY

Revision Log

Rev. No.	Brief Description of Change	Responsible Engineer	Effective Date
03			
02			
01	• This Directive has been updated as part of the Continuous Improvement Plan for Engineering Standards. • This document conforms to the new template. • References in Section 3.1 have been revised and changed from IGE to IGEM*.	Landy Ramirez	2013-MAY-01
00	• This a new document. Modified for conversion from Canadian to US Standard	Curtis Parker	2001-SEP-08

*****In 2001, the Institution of Gas Engineers (IGE) became the Institution of Gas Engineers and Managers (IGEM).

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DEFINITIONS

Terms	Definition
API	American Petroleum Institute
IGEM	Institution of Gas Engineers and Management
ft/s	feet per second
NPS	nominal pipe size

1 PURPOSE

The purpose of this Directive is to provide guidelines for adequate design and sizing of pipeline and measurement facilities. These guidelines will provide for cost effective compression, operation and maintenance and prevent the need for flow restrictions and frequent inspections.

2 SCOPE

This Directive applies to Internal Engineering Standards used in all divisions of TransCanada Pipelines Limited (TransCanada) and its wholly-owned subsidiaries, and all operated entities in the United States and Mexico.

3 REFERENCES

3.1 Regulations, Codes and Standards

3.1.1 All design shall be governed by the latest edition of the following codes and standards:

IGEM/TD/1 *Steel Pipelines and Associated Installations for High Pressure Gas Transmission*

IGEM/TD/13 *Pressure regulating installations for Natural Gas, Liquefied Petroleum Gas and Liquefied Petroleum Gas/Air*

API RP 14E *Design and Installation of Offshore Production Platform Piping Systems*

3.2 Internal References

Macleod, John. *Maximum Gas Velocity Guidelines for Compressor, Meter and Control Valve Stations*, Nova Gas Transmission Ltd., March 3, 1993.

4 POLICY

The following velocity limits that TransCanada will apply to its measurement and pipeline facilities are based on the requirements in Section 5.

- For initial design of new facilities, the piping velocity limit will be 50 ft/s.
- For the design of additions and flow increases to existing facilities, the piping velocity limit will be 70 ft/s.
- For flow increases to existing facilities (or situations when increased flow is required on a short-term basis due to system restrictions, which result in velocities over 70 ft/s), increased velocities may be allowed on an exception basis after analysis of the existing facilities and layout.

5 BACKGROUND

5.1 Gas Velocity Limit Based on Economics

The design of the piping facilities from an economic standpoint, results in optimization of the pressure drop (i.e., any added energy cost must be paid for). Hence, the balance between capital and operating expenditure must be economic and analyzed in detail at the design stage. The factors usually considered are the following:

- material cost,
- labour cost,
- operating cost,
- borrowing cost, and
- present and future operating modes.

The API RP 14E standard is not directly applicable to TransCanada but typical for the industry. It outlines acceptable pressure drops over a range of operating pressures and is displayed graphically as maximum gas velocity versus pipe size (e.g., for a pipe size of NPS 20, P = 500 psig; the acceptable velocity is 59 ft/s or for P range from 101 psig to 500 psig; the acceptable pressure drop is 0.20 to 0.49 psig/100 ft of pipe.

NOTE: This criteria cannot be directly used for situations where the pressure drop is not of economic concern, for example, at sales stations where gas pressure is reduced from the TransCanada mainline to the customer maximum allowable operating pressure through control valves. Because TransCanada's measurement facilities are subject to frequent increases in volume throughput, it would not be a prudent practice to initially design facilities to the maximum velocity limits.

5.2 Velocity Limit Based on Erosion

The limitation defined by unacceptable rates of erosion represents absolute boundaries to safe piping facility operation and must not be exceeded. This type of velocity limit applies to all elements of the pipeline system and must be evaluated for all designs.

Failure can occur when solid/liquid particles carried with the gas impinge on the piping at elbows, reducers, tees, orifices, valves and other piping discontinuities where changes in flow direction occur. The API RP 14E standard applies to a two phase flow:

The following British technical standards are recommendations for gas transmission and distribution practice, which include maximum gas velocities that pertain to the erosion:

- IGEM/TD/1 *Steel Pipelines and Associated Installations for High Pressure Gas Transmission*
- IGEM/TD/13 *Pressure regulating installations for Natural Gas, Liquefied Petroleum Gas and Liquefied Petroleum Gas/Air*

NOTE: For erosional velocity, refer to API RP 14E, Equation 2.14, Section 2.5 a. (1).

Summarizing the above two British recommendations, the following statements apply:

- Gas which is dry but may have dust should have a maximum gas velocity of 70 ft/s.
- Gas in regulating stations (and similar) should have velocities limited to 130 ft/s on the downstream side of filters.

5.3 Gas Velocity Limit Based on Indirectly Defined Damage

In contrast to the two previous gas velocity limits, this limit requires specialized and detailed analysis of the particular piping configuration. In addition, the analysis results do not directly address the velocity limits. Instead, solutions to the predicted problems are developed based on other guidelines (pulsation, noise, vibration and metering errors), which have a direct effect on gas velocities.

Control valve sizing is an example where noise guidelines are considered. At no time is the sonic flow recommended through the valve, rather a pressure drop cascade should be used. Otherwise, acoustic fatigue damage is likely to occur.

Destructive vibration of the piping may result when vortex shedding at a tee (dependent on gas velocity) produces local acoustic and structural resonance.

NOTE: The API RP14 E standard (as an alternative to the detailed studies) suggests a maximum gas velocity of 59 ft/s to reduce the potential for noise-related problems.

6 VALUE ANALYSIS / COST BENEFIT

For TransCanada facilities, the economics are determined by the system design. Because the economics of pressure loss favor low velocities, erosion and other velocity limitations discussed are rarely a concern.

For station piping, the API RP 14E standard establishes acceptable pressure drops for a range of pressures. The pressure drops listed in Table 6-1 were developed from experience by the API (American Petroleum Institute) and have been found to be an acceptable balance between capital expenditures and operating costs.

Table 6-1: Acceptable Pressure Drops for Station Piping

Operating Pressure (psig)	Acceptable Pressure Drop (psig/100 ft)
0–100	0.05–0.19
101–500	0.20–0.49
501–2000	0.50–1.12

–END OF DOCUMENT –

PURPOSE

This Specification provides Company requirements for the qualification, manufacture, inspection, and testing of end closures.

SCOPE / APPLICABILITY

This Specification applies to NPS 2 and larger end closures to be used in the Company's non-sour natural gas and non-sour liquid hydrocarbon pipeline systems in Canada, the United States, and Mexico.

This Specification does not apply to the manufacture of blind flanges.

The Responsible Engineer shall be contacted for clarification if needed.

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1 GENERAL

All end closures shall conform to the following requirements:

- End closures shall meet the additional requirements in the request for proposal and the purchase order description, where applicable.
- The Manufacturer shall supply the Company, at the time of quotation, any exceptions or alternatives to the requirements outlined in this Specification. Items covered by technical agreements need not be addressed at the time of quotation as the technical agreements apply to each order.

2 DESIGN REQUIREMENTS

End closures shall be designed in accordance with the applicable requirements of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 except for the weld bevel. The weld bevel shall be designed in accordance with the requirements of CSA Standard Z662, ASME B31.3, ASME B31.4 or ASME B31.8.

Note: Where the material is “dual certified”, it shall be permissible to use the yield strength of the higher strength material in the design of the weld bevel.

The design features outlined in Table 2-1 are required for all end closures.

Table 2-1: End Closure Design Feature Requirements

Feature	Requirements
Safety-Locking Device	End closures shall be equipped with a safety-locking device that will prevent operation unless the pressure is relieved. The device shall be accessible and shall be located and constructed to ensure its operability.
Welding End Hub	• End closures NPS 4 or larger shall be supplied with a hinge or other type of handling device attached to the welding end hub. • The specified minimum yield strength (SMYS) of the welding end hub shall not be less than two-thirds of that of the matching pipe specified on the purchase order description, where applicable, and the request for proposal.[1,2]
Notes: [1] The actual yield strength shall not be used in the above calculation unless it is equal to the specified minimum yield strength. [2] Where the material is “dual certified”, this restriction shall apply to the material with the highest specified minimum yield strength.	

2.1 End Closure Orientation

The Manufacturer shall have a design for end closures that are installed in the horizontal position as well as in the vertical position. The Company will specify the orientation on the purchase order description, where applicable, and the request for proposal.

For end closures that are to be installed in the horizontal position, the Manufacturer shall have a design for end closures that can be opened in the right direction as well as the left direction. Hinge pins shall be secured in place.

- "Opening direction right" means the door will swing to the right of an observer looking at the bore of the end closure from the door.
- "Opening direction left" means the door will swing to the left of an observer looking at the bore of the end closure from the door.

The Company will specify the opening direction on the purchase order description, where applicable, and the request for proposal.

2.2 Design Pressure

End closures shall be designed for a cold working pressure rating designated by the nominal pressure classes (PN) shown in Table 2-2 below.

Table 2-2: Cold Working Pressure Rating by Pressure Class

Nominal Pressure Class	Cold Working Pressure Rating, kPa (psi)
PN 100/ASME Class 600	10,200 (1480)
PN 150/ASME Class 900	15,300 (2220)

The required nominal pressure class is shown on the purchase order description, where applicable, and the request for proposal.

3 MATERIALS REQUIREMENTS

All materials shall be suitable for service at the minimum design metal temperature (MDMT) specified on the request for proposal and purchase order, and shall meet the requirements of this specification.

Unless otherwise specified on the purchase order description (where applicable) and the request for proposal, the seal materials shall be suitable for exposure to non-sour natural gas or non-sour liquid hydrocarbon containing by-products of processing and treatment of natural gas or liquid hydrocarbon respectively, whichever applies.

3.1 Materials for Bolting for Pressure-Containing Parts

Bolting used for pressure retention purposes shall be manufactured in accordance with the requirements of the ASME Boiler and Pressure Code, Section II, SA320, Grade L7 or L7M or L43; or SA194, Grade 4, 7, or 7M.

3.2 Materials for Pressure-Containing Parts Other Than Bolting

The following requirements apply to all pressure-containing parts other than bolting.

3.2.1 Acceptance of Materials

Cast components shall be made in accordance with an acknowledged international standard.

Materials selected for pressure-containing parts, other than bolting, shall be:

- in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section II
- submitted for review and written acceptance by the Company prior to manufacture

Note: It shall be acceptable to use "dual certified" materials; i.e., the material is certified to both an ASME SA specification and an ASTM A specification. An example of a "dual certified" material is SA 350 LF 2, Class 1/ASTM A 694 F48.

3.2.2 Heat Treatment of Test Specimens

Test specimens for mechanical tests shall be given the same heat treatment as the part they represent.

An exception is made for a part that has been tempered or stress-relieved. In this case, the part need not be retested for subsequent tempering or stress-relieving operations provided that the subsequent operations are performed at or below the temperature of the first operation.

3.2.3 Carbon Equivalent

For NPS 16 and larger end closures, the carbon equivalent (C.E.) shall be calculated for each heat of material to be used for field weld ends in accordance with the following equation and shall not exceed 0.45:

$$C.E. = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

The carbon equivalent shall be calculated using the results of either the heat analysis or a product analysis. Where the heat analysis does not include all of the elements in the carbon equivalent formula being used, a product analysis shall be conducted for all of the elements in the carbon equivalent formula being used.

3.3 Notch Toughness

All pressure-containing metallic shell components shall be Charpy V-notch tested in accordance with the requirements of ASTM A 370, except:

- bolting material 13 mm and less in diameter
- nuts of any size
- components manufactured from austenitic or duplex stainless steel
- end closures with a diameter less than NPS 16 and with a minimum design metal temperature of -29°C (-20°F) or higher where allowed by industry codes and standards, unless otherwise specified on the purchase order

3.3.1 Test Specimen and Results

Charpy V-notch tests shall be performed on the largest practical specimen size.

- The minimum average absorbed energy for any test shall be 18 J (13 ft·lb) for parts lower than Grade 359 (52 ksi), based on full-size speciments.

- The minimum average absorbed energy 27 J (20 ft·lb) for parts Grade 359 (52 ksi) or higher, based on full-size specimens.
- Where sub-size specimens must be used, the minimum energy absorption requirement shall be 18 J (13 ft·lb) or 27 J (20 ft·lb), whichever is applicable, multiplied by the ratio of the specimen width to 10 mm (0.394 in.).

3.3.2 Test Temperature

Charpy V-notch tests shall be performed at the specified minimum design metal temperature (MDMT) listed on the request for proposal and purchase order. Materials tested at lower temperatures shall be considered acceptable if the requirements of Section 3.3.1 of this specification are met at the lower test temperature.

4 PREPRODUCTION REQUIREMENTS

Prior to the commencement of production, the Manufacturer shall submit, or have previously submitted, to the Company the documents in Table 4-1 and shall have received written acceptance from the Company unless otherwise specified.

Table 4-1: Preproduction Documentation Requirements

Item	Requirements
Copy of quality program	Specific to quality program intended for the production of the ordered end closure; see Section 5.1
Copy of the quality program registration certificate	See Section 5.1
List of materials	Required for each pressure-containing part; see Section 3.2.1
Welding procedures	See Section 5.2
Definition of critical sections	Only required for pressure-containing castings; see Section 7.1.1
Drawings	Drawings shall include: • Outline dimensions • Weld end dimensions • Welding procedure numbers to be used for welds (see Section 5.2) • Bill of Materials for pressure-containing parts, including material designations • The Company materials number • The Company specification and revision date • The installation position of the end closure (See Section 2.1) • The opening direction, where applicable (See Section 2.1)

5 MANUFACTURING REQUIREMENTS

The following requirements apply to the manufacturer and manufacturing process.

5.1 Quality Program

The Manufacturer shall have and adhere to a documented quality program accepted in writing by the Company prior to production (e.g., ISO 9001, ASME BPVC Section VIII "U" Stamp).

5.2 Welding Qualification

Welding procedures for the following welds shall be submitted by the manufacturer or have been previously submitted for review and written acceptance by the Company prior to use:

- Type 1: Pressure-containing fabrication welds
- Type 2: Welds defined by the Company as critical
- Type 3: Weld repairs to the welds defined in type 1 and 2
- Type 4: Weld repairs to pressure-containing cast components that will be used on NPS 16 and larger end closures

Weld qualification requirements for these four weld types are outlined in Table 5-1.

Table 5-1: Weld Qualification Requirements

Requirements	Weld Type			
	1	2	3	4
Welds shall be made using welders and welding procedures qualified in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section IX or equivalent approved by the Company.	x	x	x	x
Welding procedure qualifications shall include CVN testing in the weld and heat-affected zone and the requirements of Section 3.3 shall be met.	x	x	x	x
Specimen quantity, location, and orientation shall be in accordance with the requirements of Paragraphs UG-84 (g) and UG-84 (h)(3) of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.	x	x	x	-

Welds not defined above shall be made using welders and welding procedures qualified in accordance with the requirements of the applicable material specification or ASME Boiler and Pressure Vessel Code, Section IX.

Where pressure-containing cast components are obtained from a sub vendor, the end closure manufacturer shall be responsible for obtaining the required weld repair procedures.

5.3 Plant Access

While work on the contract is being performed, the Company or its representative shall have free entry at all reasonable times to all parts of the Manufacturer's facilities involved in the production of the end closures ordered. All reasonable facilities shall be

provided to the Company or its representative to satisfy that the product is being furnished in accordance with this Specification.

6 PRESSURE AND OPERATIONAL TEST REQUIREMENTS

The complete end closure shall be capable of withstanding a pressure test at a pressure equivalent to 1.5 times the cold working pressure rating of the end closure. Pressure and operational testing by the Manufacturer is not mandatory.

7 INSPECTION REQUIREMENTS

All tests and inspections required by this specification shall be performed in the Manufacturer's plant prior to shipment. Tests and inspections shall be conducted to cause no undue interference with the operations of the Manufacturer's plant. The Company reserves the right to witness any test but it does not constitute a hold point unless explicitly identified.

7.1 Nondestructive Examination (NDE)

The following requirements apply to NDE of pressure-containing castings and welds, as well as reporting NDE results.

7.1.1 Pressure-Containing Castings

All pressure-containing castings for NPS 16 and larger end closures shall be fully inspected by magnetic particle examination in accordance with the requirements of MSS SP-53.

Critical sections of pressure-containing cast components shall be defined by the Manufacturer and accepted in writing by the Company.

Critical sections and weld repairs to critical sections of cast components used on NPS 16 and larger end closures shall be inspected by film radiography, in accordance with the requirements of MSS SP-54 or in accordance with a Company accepted ultrasonic inspection procedure.

7.1.2 Welds

Any NDE conducted must meet the requirements of the applicable paragraph or appendix of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 shown below:

- Radiographic inspection: Paragraph UW51.
- Ultrasonic inspection: Appendix 12.
- Magnetic particle inspection: Appendix 6.
- Liquid penetrant inspection: Appendix 8.

Table 7-1 outlines the acceptable NDE methods for use on different weld types.

Table 7-1: Acceptable NDE Method by Weld Type

Weld Type		Acceptable NDE Methods	
		Radiographic or Ultrasonic Inspection	Magnetic Particle or Liquid Penetrant Inspection
1	Pressure-containing fabrication welds.	✓	-
2	Welds defined by the Company as critical.	✓	-
3	Weld repairs to weld types 1 and 2.	✓	-
4	Major weld repairs to pressure containing parts on NPS 16 and larger end closures.	✓	-
5	Welds joining a component smaller than NPS 2 to a pressure-containing part.	-	✓
6	Welds joining a non-pressure-containing part to a pressure-containing part (e.g., lifting lugs).	-	✓
7	Field Welding ends on NPS 16 and larger end closures (inspected after final machining)	-	✓

7.1.3 Reporting

All radiographs for pressure-containing fabrication welds and for repairs to such welds shall be identified and shall be available for the Company's representative to view.

A written record of all NDE results required by Section 7.1 of this Specification shall be prepared and certified by the Manufacturer for submission to the Company in accordance with the requirements of Section 10 of this Specification.

8 DEFECT CRITERIA AND REPAIR OF DEFECTS

Pressure-containing components containing defects shall be addressed through one of the following approaches:

- The defect shall be removed, provided that the remaining wall thickness is within the limits specified in the applicable material Specification.
- The defect shall be removed and the component repaired by welding, provided that:
  - the qualification of the welders and welding procedures is in accordance with the requirements of Section 5.2 of this Specification,
  - the weld repair is made using a low hydrogen process, and
  - the weld repair is inspected in accordance with the requirements of Section 7.1.
  - All major weld repairs to pressure-containing components that will be used on NPS 16 and larger end closures shall be heat-treated.

- The component shall be rejected.

9 MARKING REQUIREMENTS

End closures shall be marked with the following information:

- Manufacturer's identification
- Size
- ASME Pressure Class; e.g., PN 100 (ASME 600) or PN 150 (ASME 900)
- Minimum design temperature in degrees Celsius or Fahrenheit
- The unique traceability number

Additional markings desired by the Manufacturer are not prohibited. However, information on interpreting these additional markings shall be provided to the Purchaser.

The traceability number shall be stamped on the end closure. Other information shall be stamped on the end closure or marked on one or more nameplates.

10 CERTIFICATION PACKAGE

The Manufacturer shall supply to the Company, prior to shipping the end closures, reports and test certificates correlated to the end closure serial number and the unique traceability number.

The reports and test certificates shall contain the following information:

- Certificate of compliance for each order item (a document that states "The product was manufactured, sampled, tested, and inspected as specified in TES-FITG-EC1, Revision X, Dated YYYY/MMM/DD; and the purchase order; and was found to have met such requirements.").
- Carbon equivalent of weld ends of NPS 16 and larger end closures.
- Mechanical and chemical test results for each pressure-containing part.
- Product analysis, where required by Section 3.2.3.
- Certificate of compliance for bolting for pressure-containing parts.
- Test records from pressure tests, where applicable.
- A written record of all NDE results required by Section 7.1 of this Specification shall be prepared and certified by the Manufacturer for submission to the Company. These records shall clearly identify the procedure number and revision level used for the examination.
- Purchase order number.
- A copy of the Company accepted drawing.
- Identification of the welding procedures and revision numbers used.

- A photocopy of the nameplate.

11 GLOSSARY

Terms and Definitions related to this Specification can be found in APPENDIX A.

12 REFERENCES

This document relies on a number of references to legislation (act, statutes, and regulations), certificates, and orders and may include directives, guidelines, standards, and codes to the extent they contain legally binding requirements for TransCanada.

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 12-1.

Table 12-1: External and Internal References

Document No.	Title
Legal Requirements	
NEB OPR SOR/99-294	National Energy Board Onshore Pipeline Regulations (NEB OPR)
49 CFR 192	Code of Federal Regulations, Title 49 Part 192, Transportation of Natural Gas and Other Gas by Pipeline: Minimum Federal Safety Standard
49 CFR 195	Code of Federal Regulations, Title 49 Part 195, Transportation of Hazardous Liquids by Pipeline: Minimum Federal Safety Standard
Various	Applicable Provincial Regulations for Provincially Regulated Systems
NOM-007-SECRE	Transporte de Gas Natural (Where applicable)
Industry Codes and Standards	
CSA Z662	Canadian Standards Association (CSA) Oil and Gas Pipeline Systems
ASME B31.3	American Society of Mechanical Engineers (ASME) Process Piping
ASME B31.4	Pipeline Transportation Systems for Liquids and Slurries
ASME B31.8	Gas Transmission and Distribution Piping Systems
ASME BPVC-II	ASME Boiler and Pressure Code, Section II, Materials
ASME BPVC-VIII	ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Rules for Construction of Pressure Vessels
ASME BPVC-IX	ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications
ASTM A370	American Society for Testing and Materials (ASTM) Standard Test Methods and Definitions for Mechanical Testing of Steel Products

Document No.	Title
MSS SP-53	Manufacturers Standardization Society (MSS) Quality Standard for Steel Castings and Forgings for Valves, Flanges, Fittings, and Other Piping Components - Magnetic Particle Examination Method
MSS SP-54	Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components - Radiographic Examination Method
ISO 9001	Quality management systems – Requirements
Internal References – Documents that Reference this Specification	
N/A	N/A
Internal References – Documents Referenced by this Specification	
N/A	N/A

13 DOCUMENT HISTORY

Rev.		
03	Description	Effective Date
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	Responsible Engineer
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Cindy Guan, P. Eng
	Impact Assessment Summary	Document Owner
	This specification was revised to streamline the documentation required for the Materials Engineering group and to make it more easily accessible to those who use it.	Cindy Guan, P. Eng

14 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A.
Industry Standards	
N/A	N/A.
General	
N/A	This Specification was updated and put into the new template.

15 APPROVALS

APPROVALS		
Originator: Derek Chen, P. Eng. Welding and Materials Engineering	Chen Xiaodi Signature	Oct. 28, 2016 Date
Reviewer: Sajjad Kazi, P.E. Welding and Materials Engineering	Kazi Signature	Oct 28, 2016 Date
Responsible Engineer: Cindy Guan, P. Eng. Welding and Materials Engineering	Guan Signature Oct 28, 2016 Date	PROFESSIONAL ENGINEER XINGSHENG (CINDY) GUAN APEGA Permit to Practice P7100 Oct 28, 2016
Management Endorsement: James Ferguson, Manager Welding and Materials Engineering	Ferguson Signature	Oct. 28, 2016 Date

APPENDIX A TERMS AND DEFINITIONS

Terms	Definitions
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Material
Bolting	Bolts, studs, cap screws, and nuts
Certificate of Compliance	A document that states that the product was manufactured, sampled, tested, and inspected in accordance with the applicable specification, the purchase order and was found to have met such requirements. Bolting and pressure containing parts smaller than NPS 2 shall be furnished with a certificate of compliance. Material test reports (MTR's) shall be supplied for components NPS 2 and larger.
CFR	Code of Federal Regulations
Company or Purchaser	TransCanada PipeLines Limited, its corporate affiliate, or its agent
CSA	Canadian Standards Association
Door	The separable part of the end closure
End closure	A fitting with a removable part or assembly, including its adapting and operating mechanism, which provides access to the bore when open, and terminates and seals the bore when closed. Blind flanges are excluded.
Heat treatment	One or more of the following methods: • Stress relieving • Normalizing • Normalizing and tempering • Quenching and tempering
Hub	The part of the end closure that is welded to the pipeline
ISO	International Organization for Standardization
Major Weld Repair	• A weld repair that is made to correct leakage. • When the depth of the cavity prepared for welding exceeds 20% of the actual wall thickness or 1 inch, whichever is smaller

Terms	Definitions
	• When the area of the cavity prepared for welding exceeds 10 sq. in.
Manufacturer or Vendor	Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.
Material Number	The number assigned to each item on a purchase order (also known as part number, catalogue number, SAP number or material master number).
MSS	Manufacturers Standardization Society
NEB	National Energy Board
NOM	Norma Oficial Mexicana
Purchase order	The purchasing document used to purchase the specified item(s)
Regulatory Authority	The national and/or local regulator having jurisdiction over the facility.
Technical Agreement	The document signed by the Company and the manufacturer, which states a mutual agreement on a technical matter.
Traceability Number	A number that will be marked on the specified item(s) to allow identification of each piece. It shall consist of the letters PO, the purchase order number, the purchase order line item number, and where applicable, a numerical suffix. The numerical suffix is only required when more than one piece is supplied for the same item number on the same purchase order.
Welding Procedure	The Welding Procedure Specification, Procedure Qualification Record, and all associated non-destructive and destructive test data

TES-FITG-SAD Full Encirclement Reinforcing Saddles Specification (CDN-US-MEX)

EDMS No.: 3779258 Rev.: 05 Status: Issued Effective Date: 2016-Nov-01
Next Review Date: 2018-Nov-01

PURPOSE

This Specification provides Company requirements for the qualification, manufacture, inspection, and testing of carbon steel full encirclement reinforcing saddles used for the reinforcement of welded branch connections.

SCOPE / APPLICABILITY

This Specification applies to carbon steel full encirclement reinforcing saddles, Grade 241 and higher (specified minimum yield strength of 35,000 psi and higher), used for the reinforcement of welded branch connections on non-sour natural gas and non-sour liquid hydrocarbon pipelines in Canada, the United States, and Mexico.

This Specification applies to all sizes of full encirclement reinforcing saddles.

The Responsible Engineer shall be contacted for clarification if needed.

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1 REQUIREMENTS

All full encirclement reinforcing saddles shall meet the additional requirements in the material description on the request for proposal and in the purchase order description.

2 DESIGN REQUIREMENTS

The Company shall calculate and determine the required length, wall thickness, and grade of the saddle. This information will be shown in the material description on the request for proposal and in the purchase order description.

The available reinforcement shall be that provided by the saddle only. The use of pads or weld build-up to provide added reinforcement shall not be permitted.

The specified minimum yield strength (SYMS) of the saddle shall not be less than 241 MPa (35,000 psi).

The reinforcing saddle shall meet all the dimensional requirements shown in APPENDIX A.

2.1 Joining Straps

Saddles shall be supplied with two longitudinal joining straps 50 mm (2 inches) in width (+/- 5 mm or +/- 1/4 inch) and with a thickness equal to the saddle wall thickness. The length of the joining straps shall be two times "D", where D is defined in APPENDIX A. Straps shall be fabricated from the same material as the saddle.

2.2 Epoxy Injection

Drilled and tapped holes for epoxy injection to further support the branch connection shall be made for all hot tap reinforcing saddles with an outlet/branch connection of NPS 10 and larger, as shown in APPENDIX B. Plugs with recessed head shall be supplied and installed, as listed in APPENDIX B.

3 MATERIALS REQUIREMENTS

Saddles shall conform to the strength and chemical composition requirements, including carbon equivalent, of MSS SP-75 or CSA Z245.11.

3.1 Weldability

Materials used in the manufacture of saddles shall be suitable for field welding. When required by the Company, the manufacturer shall demonstrate the weldability of the material in accordance with the requirements of Appendix "X2", MSS SP-75.

3.2 Heat Treatment

Saddles shall be heat treated after manufacture in accordance with applicable industry standards and requirements.

Test specimens shall be in the same heat treated condition as the saddles supplied and the sampling method shall be submitted unless otherwise agreed by the Company.

3.3 Tensile Properties

Tensile tests, where required, shall be performed in accordance with the requirements of ASTM A370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products.

- Tensile tests shall be performed by the saddle manufacturer for each heat of material with SYMS 290 MPa (42,000 psi) and higher.
- Additional tensile tests are not required for material with SYMS less than 290 MPa (42,000 psi); provided that the properties reported in the material test certificates for the starting material meet the requirements of MSS SP-75 or CSA Z245.11.

Tensile test results, including yield strength, tensile strength, and elongation, shall conform to the requirements of MSS SP-75 or CSA Z245.11.

If the tensile test results fail to conform to the specified requirements, the manufacturer may elect to retest the material. The retest procedure, including the number of retests and the acceptability of the test results, shall be subject to written agreement between the Company and the Manufacturer.

4 PREPRODUCTION REQUIREMENTS

The Company will supply the Manufacturer with the following information in the material description on the request for proposal and in the purchase order description:

- The design conditions for which the saddles are intended
- The header pipe outside diameter, wall thickness, and grade
- The branch pipe outside diameter, wall thickness, and grade
- The minimum grade of the saddle
- The minimum saddle thickness
- The minimum length of full thickness reinforcement

Prior to the commencement of production, the Company acceptance of the following documents are required.

- Types and grades of materials used for the manufacturing of saddles
- Sequence of manufacturing operations
- Heat treatment procedures, if any
- For tensile tests, the test specimen sampling methods
- Nondestructive inspection procedures
- A copy of the quality program, unless the manufacturer is registered to ISO 9001 in which case a copy of the registration certificate is sufficient
- A copy of the drawings with the detailed dimensional and ordering information filled in

The manufacturer shall inform the Company in writing of any changes to the above documents and shall obtain the written acceptance of the Company for such changes.

5 MANUFACTURING REQUIREMENTS

The following requirements apply to the manufacturer and manufacturing process.

5.1 Quality Program

The manufacturer shall have and adhere to a documented quality program that is accepted in writing by the Company prior to production (e.g., ISO 9001).

5.2 Plant Access

While work on the contract is being performed, the Company or its representative shall have free entry at all reasonable times to all parts of the Manufacturer's facilities involved in the production of the saddles ordered. All reasonable facilities shall be provided to the Company or its representative to satisfy that the product is being furnished in accordance with this Specification.

6 OPERATIONAL TEST REQUIREMENTS

Operational testing in the plant is not mandatory.

7 INSPECTION REQUIREMENTS

All tests and inspections required by this specification shall be performed in the Manufacturer's plant prior to shipment. Tests and inspections shall be conducted to cause no undue interference with the operations of the Manufacturer's plant. The Company reserves the right to witness any test but it does not constitute a hold point unless explicitly identified.

7.1 Nondestructive Examination (NDE)

All nondestructive examination procedures shall be submitted for review and written acceptance by the Company prior to use.

The bevel of the branch outlet shall be inspected by a liquid penetrant or magnetic particle technique for defects. Acceptance criteria and repair requirements shall be as defined in:

- ASME Section VIII, Division 1, Appendix 6 for magnetic particle examination.
- ASME Section VIII, Division 1, Appendix 8 for liquid penetrant examination.

8 MARKING REQUIREMENTS

Saddles shall be die stamped with the following information:

- Size; i.e., NPS ____ (header) x NPS ____ (branch)
- Specified minimum yield strength of the saddle or CSA grade
- Starting material designation; e.g., ASTM A516 Grade 70

- Manufacturer's identification
- Heat number of the starting material
- Traceability number
- An identification number matching the two halves of an individual saddle and match marks indicating how the top and bottom sections are to be aligned

Saddles shall have the following information painted on the outside:

- Company purchase order number.
- Company project number.
- Company project name.

Saddles for inventory shall have the word “inventory” painted on the outside and do not require Company project number or Company project name to be painted on the outside.

Additional markings may be applied at the manufacturer's option.

9 CERTIFICATION PACKAGE

Prior to shipping the saddle, the manufacturer shall supply to the Company, two copies of the reports and test certificates that are correlated to the traceability and material numbers. The reports and test certificates shall be in a format acceptable to the Company.

The reports and test certificates shall contain the following information:

- Chemical composition
- Carbon equivalent
- Methods of heat treatment
- Tensile test results
- Nondestructive inspection results for tests performed in accordance with the requirements of Section 7.1
- Confirmation that the reinforcing saddles were manufactured in accordance with the requirements of this Specification

10 GLOSSARY

Terms and Definitions related to this Specification can be found in APPENDIX C.

11 REFERENCES

This document relies on a number of references to legislation (act, statutes, and regulations), certificates, and orders and may include directives, guidelines, standards, and codes to the extent they contain legally binding requirements for TransCanada.

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 11-1.

Table 11-1: External and Internal References

Document No.	Title
Legal Requirements	
NEB OPR SOR/99-294	National Energy Board Onshore Pipeline Regulations (NEB OPR)
49 CFR 192	Code of Federal Regulations, Title 49 Part 192, Transportation of Natural Gas and Other Gas by Pipeline: Minimum Federal Safety Standard
49 CFR 195	Code of Federal Regulations, Title 49 Part 195, Transportation of Hazardous Liquids by Pipeline: Minimum Federal Safety Standard
Various	Applicable Provincial Regulations for Provincially Regulated Systems
NOM-007-SECRE	Transporte de Gas Natural (Where applicable)
Industry Codes and Standards	
CSA Z662	Canadian Standards Association (CSA) Oil and Gas Pipeline Systems
CSA Z245.11	Steel Fittings
ASME B31.3	American Society of Mechanical Engineers (ASME) Process Piping
ASME B31.4	Pipeline Transportation Systems for Liquids and Slurries
ASME B31.8	Gas Transmission and Distribution Piping Systems
ASME BPVC-VIII	American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section VIII, Division 1, Rules for Construction of Pressure Vessels
ASTM A370	American Society for Testing and Materials (ASTM) Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A516	Specification for Pressure Vessel Plates, Carbon Steel, for Moderate and Lower Temperature Service
ISO 9001	Quality management systems – Requirements
MSS SP-75	Manufacturers Standardization Society (MSS) Specification for High Test Wrought Butt Welding Fittings
Internal References – Documents that Reference this Specification	
N/A	N/A
Internal References – Documents Referenced by this Specification	

Document No.	Title
N/A	N/A

12 DOCUMENT HISTORY

Rev.		
05	Description	Effective Date
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	Responsible Engineer
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Derek Chen, P. Eng.
	Impact Assessment Summary	Document Owner
	This specification was revised to streamline the documentation required for the Materials Engineering group and to make it more easily accessible to those who use it.	Derek Chen, P. Eng.

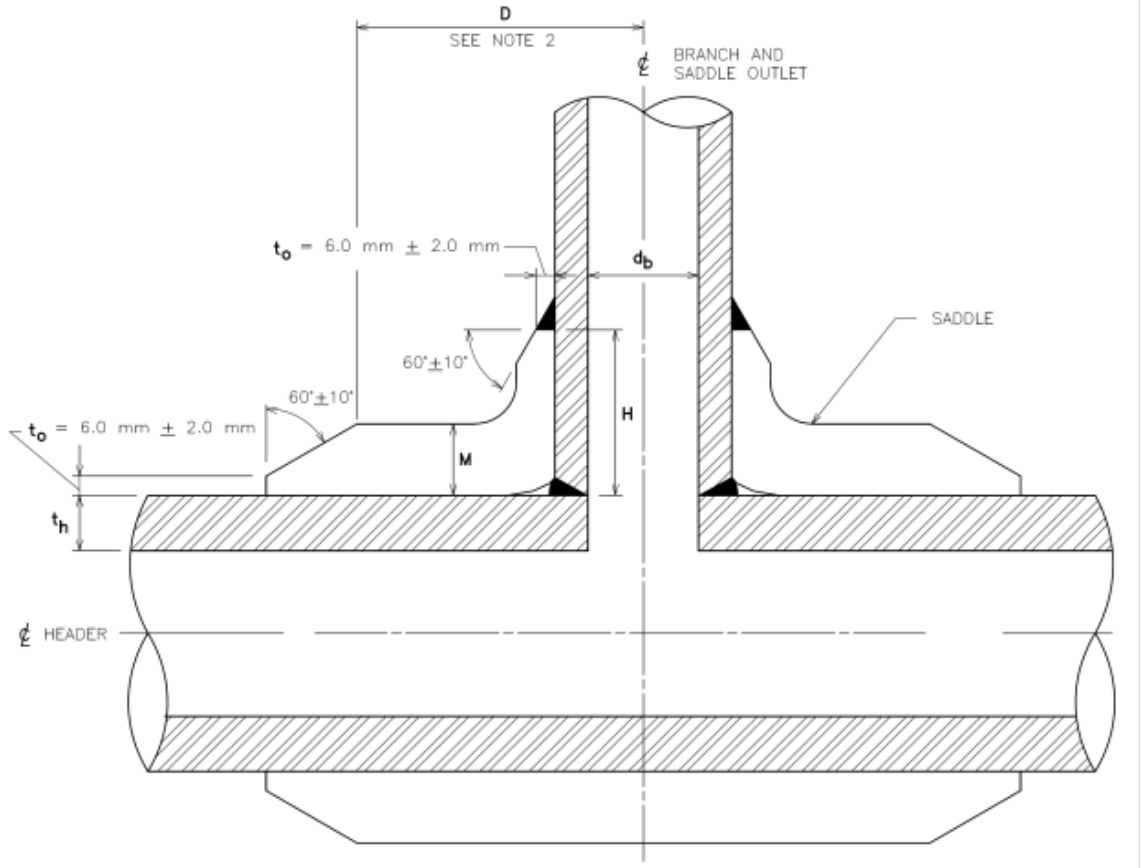
13 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A.
Industry Standards	
N/A	N/A.
General	
N/A	This Specification was updated and put into the new template.

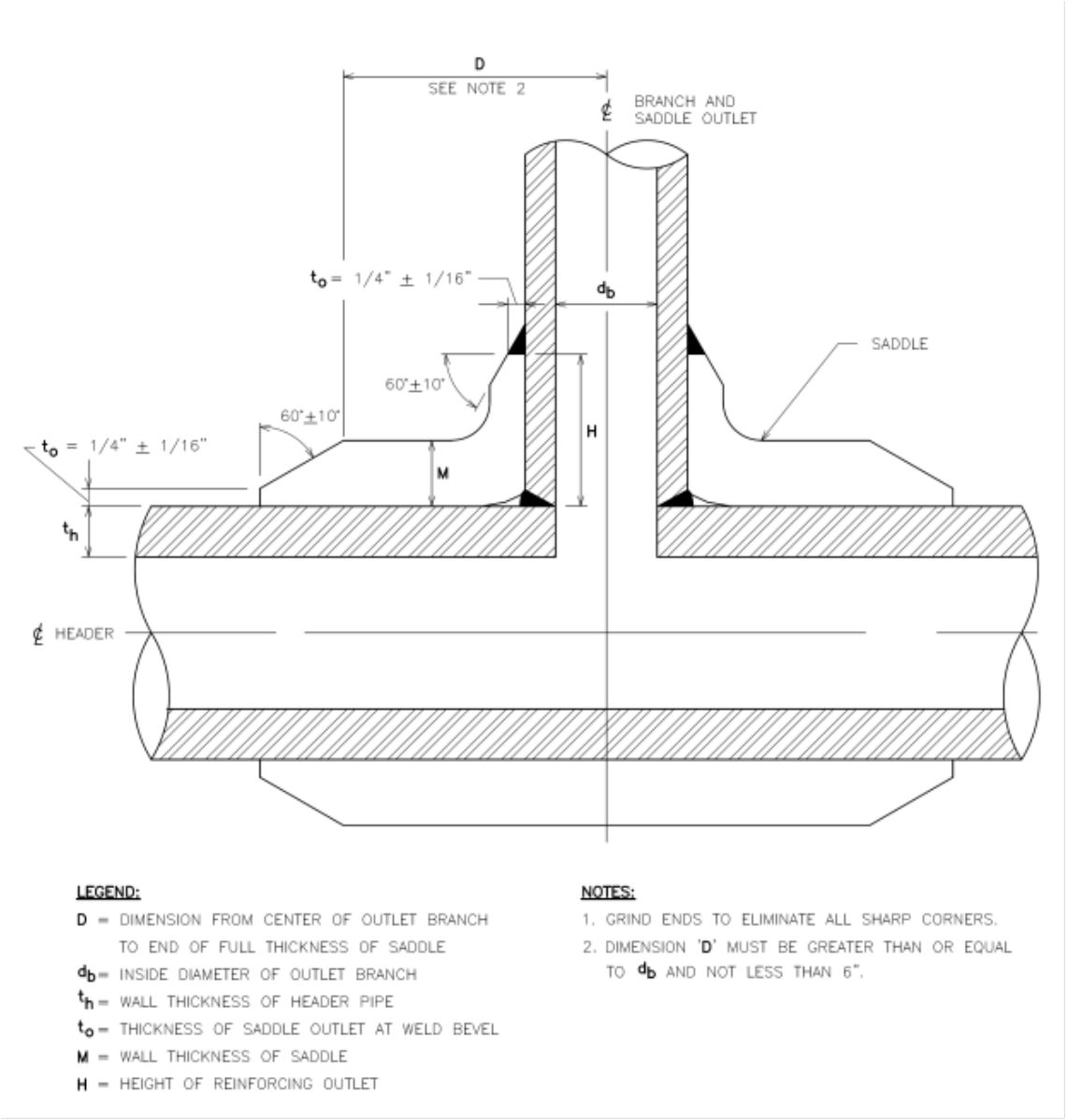
14 APPROVALS

APPROVALS		
Originator: Sajjad Kazi, P.E. Welding and Materials Engineering	Kazi Signature	Oct 28, 2016 Date
Reviewer: Cindy Guan, P. Eng. Welding and Materials Engineering	Signature	oct 28, 2016 Date
Responsible Engineer: Derek Chen, P. Eng. Welding and Materials Engineering	Signature Oct 28, 2016 Date	PROFESSIONAL ENGINEER (DEREK) CHEN APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, Manager Welding and Materials Engineering	Signature	Oct. 28, 2016 Date

APPENDIX A DIMENSIONAL REQUIREMENTS FOR FULL ENCIRCLEMENT REINFORCING SADDLES

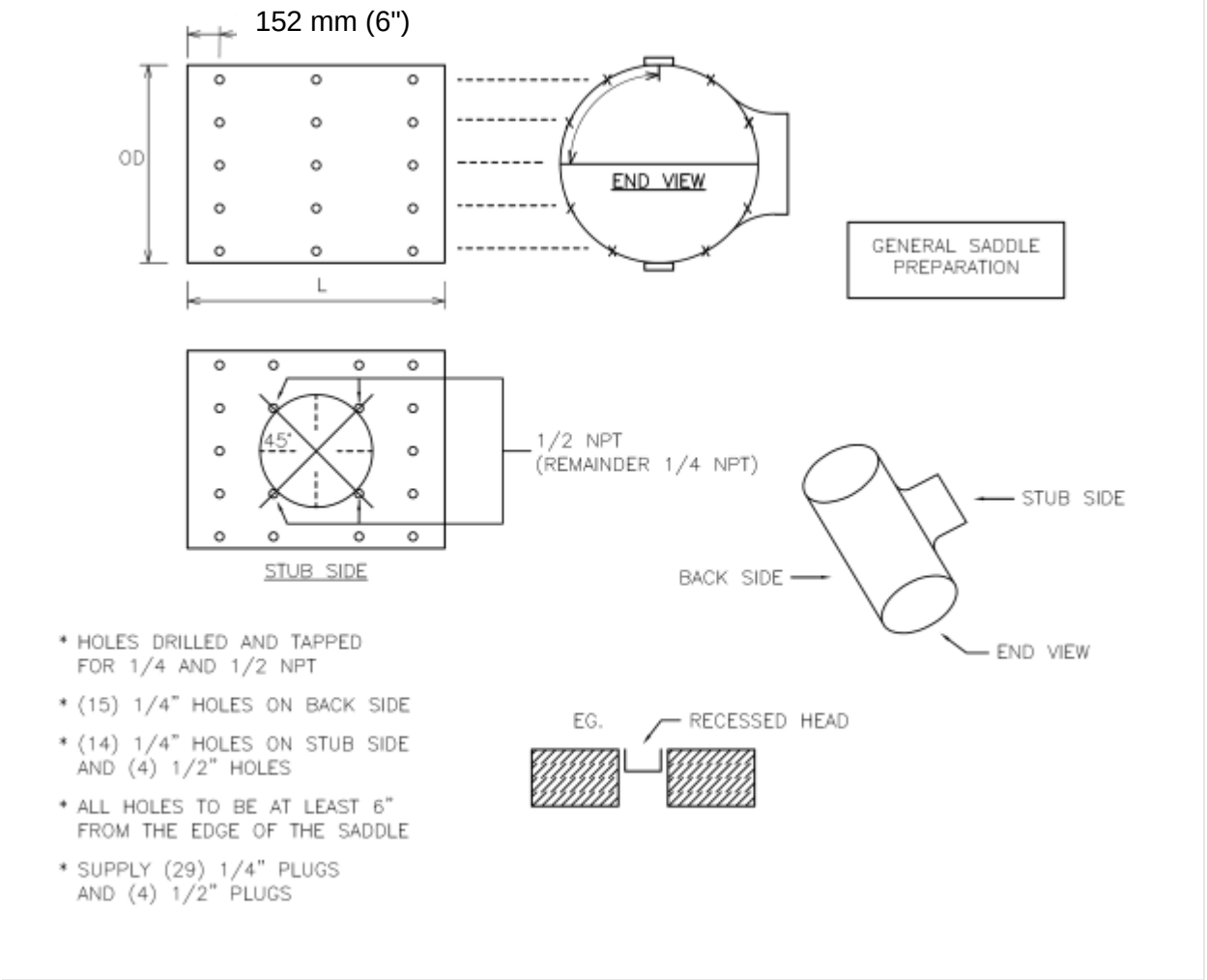


Appendix Figure A-1: Dimensional Requirements for Full Encirclement Reinforcing Saddles (SI Units)



Appendix Figure A-2: Dimensional Requirements for Full Encirclement Reinforcing Saddles (U.S. Customary Units)

APPENDIX B ARRANGEMENT OF DRILLED AND TAPPED HOLES FOR EPOXY INJECTION



Appendix Figure B-1: Arrangement of Drilled and Tapped Holes for Epoxy Injection

Note: The four ½ NPT holes shall be located in the current transition area from the run to the branch

APPENDIX C TERMS AND DEFINITIONS

Terms	Definitions
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Material
Branch Size	Nominal outside diameter of the connecting branch pipe
CFR	Code of Federal Regulations
Company or Purchaser	TransCanada PipeLines Limited, its corporate affiliate, or its agent
CSA	Canadian Standards Association
ISO	International Organization for Standardization
Manufacturer or Vendor	Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.
Material Number	The number assigned to each item on a purchase order (also known as part number, catalogue number, SAP number or material master number).
MSS	Manufacturers Standardization Society
NEB	National Energy Board
NOM	Norma Oficial Mexicana
Purchase order	The purchasing document used to purchase the specified item(s)
Purchaser	TransCanada Pipelines and its authorized representative(s) responsible for executing all or any of the engineering, procurement and construction activities
Regulatory Authority	The national and/or local regulator having jurisdiction over the facility.
Saddle	Steel casing which provides reinforcement of the welded branch connection
Saddle size	Nominal outside diameter of the header (run) pipe to which the saddle is attached
Technical Agreement	The document signed by the Company and the manufacturer, which states a mutual agreement on a technical matter.
Traceability Number	A number that will be marked on the specified item(s) to allow identification of each

Terms	Definitions
	piece. It shall consist of the letters PO, the purchase order number, the purchase order line item number, and where applicable, a numerical suffix. Note: The numerical suffix is only required when more than one piece is supplied for the same item number on the same purchase order.
Welded Branch Connection	Direct connection of pipe at 90° to the header (run) pipe by welding

TES-MATL-MD1-US Piping System Materials for Pipeline, Compression and Metering Facilities Design to -50°F		Document Type: Specification
Effective Date: 2012/03/23	Revision: 01	Status: Issued
Classification Code: ME-09	Document Owner: Materials Engineering	
Originator: Cindy Guan, P.Eng., Materials Engineering		March 23 2012 Signature/Date (signed copy on file)
Discipline Checker: Derek Chen, P. Eng., Materials Engineering		March 23 2012 Signature/Date (signed copy on file)
Discipline Checker: Gerard Lalonde, P. Eng., Piping Support		March 23/2012 Signature/Date (signed copy on file)
Responsible Engineer: Cindy Guan, P. Eng., Materials Engineering		March 23 2012 Signature/Date (signed copy on file)

BRIEF DESCRIPTION OF CHANGE

REGULATORY

- This specification complies with the relevant sections of the Department of Transportation's Code of Federal Regulations, Title 49, Parts 192 and 195.

GENERAL.

- This specification covers the material requirements of the piping systems designed in accordance with the requirements of ASME B31.3, Process Piping; ASME B31.8, Gas Transmission and Distribution Piping Systems; ASME B31.4, Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids; and TransCanada Engineering Design Standards for use in sweet natural gas and sweet liquid hydrocarbons pipeline, compression, metering and regulating facilities outside of Canada.
- This specification is intended for material selection of new piping systems. For existing systems, the Designer shall determine the best practices providing that the modifications meet the intent of the current design requirements and the codes referenced above.
- Materials included are pipe, tubing, fittings, flanges, valves, meters, and miscellaneous piping components.

TABLE OF CONTENTS

1 GENERAL

1.1 Scope

1.1.1 Intent of Specification

This specification is for pipeline systems for minimum design temperature at -50°F that will be installed in the northern United States, refer to Annex A of TED-MATL-FRAC (Zone 1) for the mimimum design temperature zone map.

This Specification covers the material requirements of the piping systems designed in accordance with the requirements of ASME B31.3, Process Piping; ASME B31.4, Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids; ASME B31.8, Gas Transmission and Distribution Piping Systems; CFR Title 49 Part 192, Transportation of Natural Gas and Other Gas by Pipeline: Minimum Safety Standards, and any amendment or errata issued by DOT; CFR Title 49 Part 195, Transportation of Hazardous Liquids by Pipeline and any amendment or errata issued by DOT; and TransCanada Engineering Design Standards for use in sweet natural gas and sweet liquid hydrocarbons pipeline, compression, metering, and regulating facilities.

This Specification is intended for material selection of new piping systems. For existing systems, the Designer shall determine the best practices providing that the modifications meet the intent of the current design requirements and the codes referenced above.

Materials included are pipe, tubing, fittings, flanges, valves, meters, and miscellaneous piping components.

1.1.2 Limitations

All materials described in this Specification are suitable for use in the specific piping system listed in Table 1. The Designer shall select the wall thickness and pressure ratings to suit the design conditions. The selected materials shall be in conformance with the applicable engineering standards, specifications, design philosophies, and directives.

1.2 Definitions

a) Specified Minimum Yield Strength (SMYS) - The minimum yield strength prescribed by the specification or standard under which a material is manufactured.

b) ASTM - American Society for Testing and Materials

c) ASME - American Society of Mechanical Engineers

d) Piping System - A facility; including pipe, valves, fittings, flanges, vessels, and other attached appurtenances; used to convey natural gas or other fluids such as liquefied petroleum gases, air, steam, solution of ethylene glycol in water, oils used in compressor stations, and sewage effluent.

1.3 Reference Publications

1.3.1 American Society of Mechanical Engineers (ASME)

B31.3 Process Piping

B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids

B31.8	Gas Transmission and Distribution Piping Systems
B16.5	Pipe Flanges and Flanged Fittings
B16.9	Factory-Made Wrought Steel Buttwelding Fittings
B16.11	Forged Fittings Socket Welding and Threaded
B16.20	Metallic Gaskets for Pipe Flanges, Ring-Joint Spiral Wound and Jacketed
B16.21	Nonmetallic Flat Gaskets for Pipes Flanges
B16.25	Buttwelding Ends
B16.34	Valves Flanged Threaded and Welding End
B16.47	Large Diameter Steel Flanges
B16.49	Factory –Made Wrought Steel Buttwelding Induction Bends for Transportation and Distribution Systems
B36.10	Welded and Seamless Wrought Steel Pipe
B36.19	Stainless Steel Pipe

1.3.2 ASTM

D 1527 Standard Specification for ABS Plastic Pipe Schedules 40 and 80
D 2235 Standard Specification for ABS Plastic Pipe Schedules 40 and 80
D 2466 Standard Specification for PVC Plastic Pipe Schedule 40
D 2467 Standard Specification for PVC Plastic Pipe Schedule 80

1.3.3 DOT

CFR Title 49 Part 192	Transportation of Natural Gas and Other Gas by Pipeline: Minimum Safety Standards and any amendment or errata issued by DOT
CFR Title 49 Part 195	Transportation of Hazardous Liquids by Pipeline and any amendment or errata issued by DOT

1.3.4 Manufacturers Standardization Society (MSS)

MSS SP-44	Steel Pipeline Flanges
MSS SP-75	Specification for High-Test, Wrought, Butt-Welding Fittings
MSS SP-80	Bronze Gate, Globe, Angle and Check Valves
MSS SP-83	Class 3000 Steel Pipe Unions, Socket Welding and Threaded
MSS SP-95	Swage Nipples and Bull Plugs
MSS SP-97	Integrally Reinforced Forged Branch Outlet Fittings - Socket Welding, Threaded and Buttwelding Ends

1.3.5 TransCanada Engineering Standards and Specifications

TES-PIPE-EW-US	Specification for Electric-Welded Pipe
TES-PIPE-SAW-US	Specification for Double Submerged Arc Welded Pipe
TES-FITG-EC1-US	End Closures (EC-1)
TES-FITG-CIF-US	Contoured Insert Fitting
TES-FITG-LD-US	Specification for Carbon Steel Buttwelding Fittings, Grade 290 and Higher
TES-FITG-T01-US	Instrument Tube Fitting, Instrument Pipe Fitting and Tubing Material Spec.
TES-PIPE-P8-US	Orifice Meter Tube Pipe
TES-FLGE-LD-US	Specification for Steel Flanges ≥ NPS 16

TES-USON-US1-US	Ultrasonic Meters
TES-VALV-LD-US	Specification for Steel Valves ≥ NPS 16
TES-MATL-PV1-US	Specification for Pressure Vessels

2 PIPING SYSTEMS

2.1 Purpose and Description

For purposes of simplifying the design and drafting procedures, and for proper identification of the materials and parts, all piping within the pipeline, compression, metering, and regulating facilities is divided into piping systems.

The piping systems are identified and described in Table 1. Materials for specific piping systems are listed in Tables 2 to 13.

2.2 Design Conditions

The materials specified for use in the piping systems containing natural gas and liquid hydrocarbons shall be designed to the requirements of ASME B31.3, ASME B31.4, ASME B31.8, and CFR Title 49 Part 192 & 195 whichever is applicable.

2.3 Abbreviations

The following abbreviations are used in this Specification:

PN	Nominal pressure class
NPS	Nominal pipe size
OD	Nominal outside diameter
ID	Nominal inside diameter
WT	Nominal wall thickness
RF	Raised face
FF	Flat face
NPT	National pipe thread
BW	Buttwelding
SW	Socket welding
SF	Socket Fusion
WNRF	Raised face welding neck
SWRF	Raised face socket welding

2.4 Tubing and Instrument Tube Fittings

All tubing and instrument tube fittings shall meet the requirements of TES-FITG-T01-US.

2.5 Unlisted Materials

Materials required for all pipeline systems and pressure containing compressor station systems shall be specified on design drawings, material requisitions, and purchase orders in accordance with this Specification. Unlisted pressure-containing components materials may be used only with the prior approval of TransCanada's Materials Engineer and in a manner that complies with the requirements for alternative materials contained in the applicable design code.

2.6 Pipe Wall Thickness

Wall thickness of pipe shall be determined in accordance with ASME B31.3, B31.4 or ASME B31.8.

As a quick reference, maximum design pressures are provided for Schedule 40 and Schedule 80 pipe that is NPS 14 and smaller in Appendices B and C.

2.7 Flanges

Maximum operating pressures for ASME flanges are listed in ASME B16.5 based on a maximum operating temperature of 100°F. Maximum operating pressures for MSS flanges are listed in MSS-SP-44 based on a maximum operating temperature of 250°F. For operation above these temperatures, the maximum operating pressures are derated in accordance with the tables in ASME B16.5/MSS-SP-44.

As a quick reference, maximum operating pressures are provided based on flange material selected and typical operating temperatures in Appendix A.

2.8 Flange Bolting and Gaskets

Dimensions of bolting and gaskets are listed in Appendices E and F. The bolting dimensions shall be adjusted for spacers and wafer type valves intended to fit between flanges.

2.9 Valves

The description of material requirements are listed in TES-VALV-LD-US.

ASME B16.34 requires valve ratings to be in accordance with the ASME B16.5 flange class rating system (e.g., Class 150, 300, 400, 600, 900). However, some manufacturers use alternate systems for pressure ratings (i.e. PN 20, 50, 68, 100, 150, 2000#, 3000#, and 6000#). When ordering valves not rated in accordance with the ASME B16.34 class rating system, written confirmation of maximum cold working pressure shall be obtained from the approved manufacturers.

2.10 Components Having Requirements for Proven Notch Toughness

For all items purchased to TransCanada specifications, the applicable design temperature shall be included with the ordering designation on design drawings, material requisitions and purchase orders.

For all pressure containing components for sweet natural gas and sweet liquid hydrocarbons service NPS 2 and larger and purchased to US industry standards, a minimum design temperature of +23°F or -50°F shall be specified on design drawings, material requisitions, and purchase orders.

2.11 Material Descriptions

Material Descriptions in Avantis shall be prepared and approved by the originating process and submitted to the Designer and Materials Engineer for final approval.

2.12 D/t Ratio

The pipe outside diameter to wall thickness ratios (D/t) should not exceed the values listed in

Appendix D. The table encompasses the more common pipe diameters used in the TransCanada system and is based on favorable manufacturing and field construction experience. For pipe diameters not included, D/t may be found by interpolation.

2.13 Coating Materials

All piping, valves and equipment shall be coated in accordance with the requirements of TransCanada coating specifications.

2.14 Threaded Connections

Except for auxiliary connections such as drains, valve body bleeds, or instrumentation taps, the use of threaded connections on permanently buried installations is not permitted. All other underground connections to components used in gas pipeline and compressor station systems shall be made by welding or by the use of flanges.

Seal welding of above and below ground threaded connections is prohibited unless otherwise approved by the Designer or Welding Specialist. Such approval would only be considered on a case by case basis.

3 TEST REPORTS

3.1 Material Less Than NPS 2

Either a Certificate of Compliance or a Material Test Report shall be supplied for all materials that are smaller than NPS 2.

3.2 Material NPS 2 and Larger

A Material Test Report shall be supplied for all materials that are NPS 2 and larger.

Table 1: Summary of Piping Systems

Piping System Designation	Fluid Handled	Design Pressure	Design Temperature	Description	Material Table
High Pressure Gas / Oil - Pipeline Facility	Sweet natural gas / oil	Designer to Specify	23°F to 167°F	Line pipe	2
High Pressure Gas / Oil - Pipeline Assemblies	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Pipeline assemblies, hot taps, crossovers (tieovers), blowdowns, launchers and receivers	3
High Pressure Gas / Oil - Meter Station	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Meter Station piping	4
High Pressure Gas / Oil - Compression Facility	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Compressor station suction, discharge and recycle piping	5
Power Gas	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Supply to operators and control devices	5
Utility Gas	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Fuel gas piping to APU, PPU, boilers and gas burning appliances	5
Compressor Fuel Gas	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Compressor fuel gas piping upstream of final fuel gas filter	5
Compressor Fuel Gas	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Compressor fuel gas piping downstream of final fuel gas filter	6
Control Gas & Seal Gas	Sweet natural gas / oil	Designer to Specify	-50°F to 167°F	Control gas to instrumentation and compressor seal gas	6
Compressor Lube Oil	Mineral or PE oil	Designer to Specify	23°F to 248°F	Lubricating and make-up oil	7
Compressor Seal Oil and Hydraulic Oil	Mineral, hydraulic or PE oil	Designer to Specify	23°F to 248°F	Seal and hydraulic oil	7
Fire Suppression - Gaseous	Inergen, Halon or CO_2	Designer to Specify	-50°F to 167°F	Piping from cylinders to nozzles	8
Foam Systems & Water Mist Systems	Foam concentrate and Water	Designer to Specify	23°F to 167°F	Foam concentrate and water piping between system components	9
Potable Water	Water	80 Psig	23°F to 167°F	Fresh water, water treatment and storage	10
Heating Water	Glycol-water 50:50 mixture	160 Psig	23°F to 248°F	Glycol/water for heating	11
Jacket Cooling Water	Glycol-water 50:50 mixture	160 Psig	23°F to 248°F	Compressor package jacket cooling water piping	11
Compressed Air	Air	150 Psig	23°F to 167°F	Shop, power, bleed, and instrument air	12
Drainage	Storm, waste and effluents disposal	80 Psig	23°F to 167°F	Sanitary and storm drainage and vent	13

Table 2: High Pressure Gas / Oil - Pipeline Facility

Piping System: Pipeline Facility			**Fluid Handled: Sweet Natural Gas & Oil**	**Design Pressure: Designer to Specify**	**Design Temperature: 23°F to 167°F**
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Line Pipe	2 3 to 14 10 to 24 16 to 48	Bevel Bevel Bevel Bevel	API 5L Gr. B, or ASTM A106 Gr. B, or ASTM A333 Gr. 6, Seamless API 5L PSL 2, or ASTM A333 Gr. 6, Seamless TES-PIPE-EW-US TES-PIPE-SAW-US		
Induction Bends	All	Bevel	ASME B16.49		
3D Elbows	16 to 48	Bevel	TES-FITG-LD-US		

Table 3: High Pressure Gas / Oil - Pipeline Assemblies

Piping System: Pipeline Assemblies			Fluid Handled: Sweet Natural Gas / Oil	Design Pressure: Designer to Specify	Design Temperature: - 50°F To 167°F
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Tubing	Up to ½ ⅝ to ⅞ 1	Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Instrument Pipe Fittings	¼ to 1½	NPT	Cadmium plated carbon steel or stainless steel		
Pipe	½ to 1½ 2 3 to 14 16 to 48	Plain Bevel Bevel Bevel	API 5L Gr.B or ASTM A106 Gr. B, Sch. 80, seamless ASTM A333 Gr. 6 seamless, Sch. 80 ASTM A333 Gr. 6 seamless or API 5L PSL2 c/w toughness test @-50°F seamless, or TES-PIPE-EW-US TES-PIPE-EW-US OR TES-PIPE-SAW-US		
Pipe Fittings	½ to 1½ 2 to 14 16 to 48	SW BW BW	ASME B16.11 & ASTM A105, 3000# ASME B16.9 & ASTM A420 WPL6, to match pipe TES-FITG-LD-US, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A105, 3000#		
Mueller Tees	½ to 1½	NPT	ASTM A105, 1440 Psig		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106 Gr. B, Sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, Sch. 80		
Flanges (See Appendix A)	½ to 1½ 2 to 14 16 to 48	SWRF WNRF WNRF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1, to match pipe TES-FLGE-LD-US, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 24 26 to 48	RF RF RF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1 ASME B16.47 & ASTM A350 LF2 Class 1		
Closures	All	BW	TES-FITG-EC1-US		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A105, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A350 LF2 Class 1, XS		
CIF's	3 to 12		TES-FITG-CIF-US, min. run size NPS 20, to match WT		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.21, Wire reinforced non asbestos 1/16 in (preferred) Alternate: ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	CS or SS body, stem & bonnet; non metallic seat, 6000#		

Valves	½ to 1½ 2 to 14 16 to 48	SW or NPT RF or BW RF or BW	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D c/w toughness test @-50°F TES-VALV-LD-US
Pressure Vessels	All		TES-MATL-PV1-US

Table 4: High Pressure Gas / Oil - Meter Station

Piping System: Meter Station			Fluid Handled: Sweet Natural Gas / Oil	Design Pressure: Designer to Specify	Design Temperature: - 50°F To 167°F
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Tubing	Up to ½ ⅝ to ⅞ 1	Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 14 16 to 48	Plain Bevel Bevel Bevel	API 5L Gr. B, ASTM A106 Gr. B, seamless, Sch. 80 ASTM A333 Gr. 6, seamless, Sch. 80 ASTM A333 Gr. 6 seamless, API 5L PSL2 c/w toughness test @-50°F, or TES-PIPE-EW-US TES-PIPE-EW-US OR TES-PIPE-SAW-US		
Pipe Fittings	½ to 1½ 2 to 14 16 to 48	SW BW BW	ASME B16.11 & ASTM A105, 3000# ASME B16.9 & ASTM A420 WPL6, to match pipe TES-FITG-LD-US; to match pipe		
Instrument Pipe Fittings	¼ to 1½	NPT	Cadmium plated carbon steel or stainless steel		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A105, 3000#		
Mueller Tees	½ to 1½	NPT	ASTM A105, 1440 Psig		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106 Gr. B, Sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, Sch. 80		
Flanges (See Appendix A)	½ to 1½ 2 to 14 16 to 48	SWRF WNRF WNRF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1, to match pipe TES-FLGE-LD-US, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 24 26 to 48	RF RF RF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1 ASME B16.47 & ASTM A350 LF2, Class 1		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A105, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A350 LF2 Class 1, XS		
CIF's	3 to 6		TES-FITG-CIF-US, min. run size NPS 20, to match WT		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	CS or SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 14 16 to 48	SW or NPT RF or BW RF or BW	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D c/w toughness test @-50°F TES-VALV-LD-US		
Meters	All	WxRF or RFxRF	TES-ORIF-OF1-US (orifice), TES-TBIN-FE-US (turbine), or TES-USON-US1-US (ultrasonic)		

Piping System: Meter Station			Fluid Handled: Sweet Natural Gas / Oil	Design Pressure: Designer to Specify	Design Temperature: - 50°F To 167°F
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Meter Tube, Orifice	Up to 12	Bevel	TES-PIPE-P8-US		
Meter Tube, Ultrasonic	3-30	Bevel	TES-PIPE-P8-US		
Meter Tube, Turbine	Up to 12	Bevel	ASTM A333 Gr. 6, Seamless		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 5: High Pressure Gas / Oil - Compression Facility

Piping System: Compressor Plant, Power Gas, Utility Gas, and Fuel Gas u/s of Coalescing Filter			**Fluid Handled: Sweet Natural Gas / Oil**	**Design Pressure: Designer to Specify**	**Design Temperature: - 50°F To 167°F**
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 14 16 to 48	Plain Bevel Bevel Bevel	ASTM A106 Gr. B or API 5L Gr. B, Seamless, Sch. 80 ASTM A333 Gr. 6, Seamless, Sch. 80 ASTM A333 Gr. 6, Seamless or API 5L PSL2 c/w toughness test @- 50°F Seamless, or TES-PIPE-EW-US TES-PIPE-EW-US OR TES-PIPE-SAW-US		
Pipe Fittings	½ to 1½ 2 to 14 16 to 48	SW BW BW	ASME B16.11 & ASTM A105, 3000# ASME B16.9 & ASTM A420 WPL6, to match pipe TES-FITG-LD-US; to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A105, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106 Gr. B, XXS		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, XXS		
Flanges (See Appendix A)	½ to 1½ 2 to 14 16 to 48	SWRF WNRF WNRF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1, to match pipe TES-FLGE-LD-US, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 24 26 to 48	RF RF RF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1 ASME B16.47 & ASTM A350 LF2, Class 1		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A105, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A350 LF2 Class 1, XS		
CIF's	3 to 6		TES-FITG-CIF-US, min. run size NPS 20, to match WT		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		PN 20/50/68 (Class 150/300/400): ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in (preferred); PN 100/150 (Class 600/900): ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 14 16 to 48	SW or NPT RF or BW RF or BW	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D c/w toughness test @- 50°F TES-VALV-LD-US		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 6: High Pressure Gas / Oil - Compressor Fuel (d/s of filter), Control & Seal Gas

Piping System: Compressor Fuel Gas d/s of Coalescing Filter, Control & Seal Gas			**Fluid Handled: Sweet Natural Gas / Oil**	**Design Pressure: Designer to Specify**	**Design Temperature: -50°F To 167°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 6	Plain Bevel Bevel	ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316		
Pipe Fittings	½ to 1½ 2 to 6	SW BW	ASME B16.11 & ASTM A182 Gr. F304/F316, 3000# ASME B16.9 & ASTM A403 Gr. WP304/WP316, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A182, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A312 Gr. TP304/TP316, Sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A403 Gr. WP304/WP316		
Flanges (See Appendix A)	½ to 1½ 2 to 6	SWRF WNRF	ASME B16.5 & ASTM A182 Gr. F304/F316 ASME B16.5 & ASTM A182 Gr. F304/F316, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 6	RF RF	ASME B16.5 & ASTM A182 Gr. F304/F316 ASME B16.5 & ASTM A182 Gr. F304/F316		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A182 Gr. F304/F316, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A182 Gr. F304/F316, 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A182 Gr. F304/F316, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A182 Gr. F304/F316, XS		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in Alternate: ASME B16.21, Wire reinforced non asbestos, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 6	SW or NPT RF	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 7: Auxiliary Systems - Lubrication Oil, Seal Oil & Hydraulic Oil

Piping System: Lubrication Oil, Seal Oil & Hydraulic Oil			**Fluid Handled: Lube/Hydraulic Oil**	**Design Pressure: Designer to Specify**	**Design Temperature: 23°F To 248°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 6	Plain Bevel Bevel	ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316		
Pipe Fittings	½ to 1½ 2 to 6	SW BW	ASME B16.11 & ASTM A182 Gr. F304/F316, 3000# ASME B16.9 & ASTM A403 Gr. WP304/WP316, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A182, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A312 Gr. TP304/TP316, Sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A403 Gr. WP304/WP316		
Flanges (See Appendix A)	½ to 1½ 2 to 6	SWRF WNRF	ASME B16.5 & ASTM A182 Gr. F304/F316 ASME B16.5 & ASTM A182 Gr. F304/F316, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 6	RF RF	ASME B16.5 & ASTM A182 Gr. F304/F316 ASME B16.5 & ASTM A182 Gr. F304/F316		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A182 Gr. F304/F316, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A182 Gr. F304/F316, 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A182 Gr. F304/F316, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A182 Gr. F304/F316, XS		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		PN 20/50/68 (Class 150/300/400): ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in PN 100/150 (Class 600/900): ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 6	SW or NPT RF	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 8: Auxiliary Systems - Fire Suppression - Gaseous

Piping System: High Pressure Fire Suppression			**Fluid Handled: Halon/Inergen/CO_2**	**Design Pressure: Designer to Specify**	**Design Temperature: - 50°F To 167°F**
ITEM	**SIZE (NPS)**	**ENDS**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2	Plain Bevel	ASTM A106 Gr. B, seamless, Sch. 80 ASTM A333 Gr. 6 seamless, Sch. 80		
Pipe Fittings	½ to 1½ 2	SW BW	ASME B16.11 & ASTM A105, 3000# ASME B16.9 & ASTM A420 WPL6, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A105, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106 Gr. B, XXS		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, XXS		
Flanges (See Appendix A)	½ to 1½ 2	SWRF WNRF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2	RF RF	ASME B16.5 & ASTM A105 ASME B16.5 & ASTM A350 LF2 Class 1		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A105, 3000# (pref.) or 6000#		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.20, Spiral Wound with Type 304SS Winding c/w 1/8 in internal & external CS Ring (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2	SW or NPT RF	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 9: Auxiliary Systems - Fire Suppression - Foam & Water Mist

Piping System: Foam Systems, Water Mist Systems			**Fluid Handled: Foam/Water**	**Design Pressure: Designer to Specify**	**Design Temperature: 23°F To +167°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 6	Plain Bevel Bevel	ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316, Sch. 80 ASTM A312 Gr. TP304/TP316, Sch. 40		
Pipe Fittings	½ to 1½ 2 to 6	SW BW	ASME B16.11 & ASTM A182 Gr. F304/F316, 3000# ASME B16.9 & ASTM A403 Gr. WP304/WP316, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A182, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A312 Gr. TP304/TP316, Sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A403 Gr. WP304/WP316		
Flanges (See Appendix A)	½ to 1½ 2 to 6	SWRF WNRF	ASME B16.5 & ASTM A182 Gr. F304/F316 ASME B16.5 & ASTM A182 Gr. F304/F316, to match pipe		
Blind Flanges (See Appendix A)	½ to 1½ 2 to 6	RF RF	ASME B16.5 & ASTM A182 Gr. F304/F316, Class 150 ASME B16.5 & ASTM A182 Gr. F304/F316, Class 150		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A182 Gr. F304/F316, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A182 Gr. F304/F316, 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A182 Gr. F304/F316, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A182 Gr. F304/F316, XS		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 6	SW, NPT RF	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 10: Auxiliary Systems - Potable Water

Piping System: Potable Water			Fluid Handled: Fresh Water	Design Pressure: 80 Psig	Design Temperature: 23°F To 167°F
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe - Galvanized	½ to 2 3	NPT NPT	ASTM A53 Galvanized, sch. 80 for general above ground service ASTM A53 Galvanized, sch. 40 for general above ground service		
Pipe - Copper	All	Plain	ASTM B88 Type L hard, for above ground control/service building only ASTM B88 Type K soft, for below ground control/service building only		
Pipe - CPVC	½ to 2	Plain	ASTM D 2241		
Pipe - Polyethylene	½ to 2	Plain	ASTM D 2239		
Fittings - Galvanized	½ to 3	NPT	ASME B16.11 & ASTM A105 Galvanized, 3000#		
Fittings - Copper	All	Soldered	ASME B16.22		
Fittings - CPVC	½ to 2	SF	ASTM D 2466		
Fittings -Polyethylene	½ to 2	SF	ASTM D 2239		
Unions	½ to 3	NPT	MSS-SP-83 & ASTM A105 Galvanized, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A53 Galvanized, sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB Galvanized, sch. 80		
Flanges (See Appendix A)	½ to 3	RF, NPT	ASME B16.5 & ASTM A105 Galvanized, Class 150		
Blind Flanges (See Appendix A)	½ to 3	RF	ASME B16.5 & ASTM A105 Galvanized, Class 150		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105 Galvanized, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB Galvanized, 6000# (solid)		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 3	Soldered or NPT	MSS SP 80, Class 125 bronze body		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 11: Auxiliary Systems - 50:50 Water/Glycol

Piping System: Heating & Cooling Water			**Fluid Handled: 50:50 Water/Glycol**	**Design Pressure: 160 Psig**	**Design Temperature: 23°F To 248°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065" WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083" WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2 3 to 8	Plain Bevel Bevel	API 5L Gr.B or ASTM A106 Gr. B, sch. 80, seamless API 5L Gr.B or ASTM A106 Gr. B or A333 Gr. 6 seamless, sch. 80 API 5L PSL2 or ASTM A333 Gr. 6 seamless, sch. 40		
Pipe Fittings	½ to 1½ 2 to 8	SW BW	ASME B16.11 & ASTM A105, 3000# MSS-SP-75 or ASTM A420 WPL6, to match pipe		
Unions	½ to 1½	SW	MSS-SP-83 & ASTM A105, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106 Gr. B, XXS		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, XXS		
Flanges	½ to 1½ 2 to 8	SWRF WNRF	ASME B16.5 & ASTM A105, Class 150 ASME B16.5 (for dimension only) & MSS-SP-44 or ASTM A350 LF2 Class 1, Class 150, to match pipe		
Blind Flanges	½ to 1½ 2 to 8	RF RF	ASME B16.5 & ASTM A105, Class 150 ASME B16.5 (for dimension only) & MSS-SP-44 & ASTM A350 LF2 Class 1, Class 150		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB 6000# (solid)		
O'lets	½ to 1½	SW or NPT	MSS SP-97 & ASTM A105, 3000# (pref.) or 6000#		
Weldolets	2		MSS SP-97 & ASTM A105 XS or A350 LF2 Class 1, XS		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2 to 8	SW, NPT RF	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 12: Auxiliary Systems - Compressed Air

Piping System: Shop and Instrument Air			**Fluid Handled: Air**	**Design Pressure: 150 Psig**	**Design Temperature: 23°F To 167°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
Tubing	Up to ⅜ ½ ⅝ & ¾ ⅞ & 1	Plain Plain Plain Plain	ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.035“ WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.049” WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.065” WT ASTM A269 Gr. TP304/316, seamless, bright, annealed, 0.083” WT		
Tube Fittings	All	Swagelok	ASTM A182 Gr. F316		
Pipe	½ to 1½ 2	NPT NPT	API 5L Gr.B or ASTM A106 Gr. B, sch. 80, seamless API 5L Gr.B or ASTM A106 Gr. B or ASTM A333 Gr. B, sch. 80, seamless		
Pipe Fittings	½ to 2	NPT	ASME B16.11 & ASTM A105, 3000#		
Unions	½ to 2	NPT	MSS-SP-83 & ASTM A105, 3000#		
Nipples	½ to 1½	SW or NPT	ASTM A733 & ASTM A106, sch. 80		
Swage Nipples	½ to 1½	SW or NPT	MSS SP-95 & ASTM A234 WPB, sch. 80		
Flanges	½ to 2	RF, NPT	ASME B16.5 & ASTM A105, Class 150		
Blind Flanges	½ to 2	RF	ASME B16.5 & ASTM A105, Class 150		
Pipe Plugs	½ to 1½	NPT	ASME B16.11 & ASTM A105, 6000#		
Bull Plugs	½ to 1½	NPT	MSS SP-95 & ASTM A234 WPB, 6000# (solid)		
Studs	All		ASTM A320 Gr. L7		
Nuts	All		ASTM A194 Gr. 4 or Gr. 7		
Gaskets	All		ASME B16.21, Permanite AF2100 Glass fibre, 1/16 in (preferred) Alternate: ASME B16.21, Garlock HTC 9850, 1/16 in		
Instrument Valves	Up to ¾	NPT	SS body, stem & bonnet; non metallic seat, 6000#		
Valves	½ to 1½ 2	SW or NPT RF or NPT	ASME B16.34 & ASTM A105, 2000#WOG min. API 6D		
Pressure Vessels	All		TES-MATL-PV1-US		

Table 13: Auxiliary Systems - Drainage

Piping System: Drainage			**Fluid Handled: Effluents**	**Design Pressure: 80 Psig**	**Design Temperature: 23°F To 167°F**
ITEM	**SIZE (NPS)**	**END CONN.**	**MATERIAL SPECIFICATION**		
ABS Pipe	All	Plain	ASTM D 2661		
PVC Pipe	All	Plain	ASTM D 2665		
Carbon Steel Pipe	2 to 10	Bevel	API 5L PSL2 or ASTM A333 Gr. 6, Seamless (for compressor floor drainage to holding tank)		
Pipe Fittings	2 3 to 10	BW BW	ASME B16.9 & ASTM A420 WPL6, to match pipe MSS-SP-75 to match pipe		
Cast Iron to Steel Pipe Connections	All	Mechanical Joint	Stainless Steel Clamp & Viton Sheet		
ABS Fittings	All	Solvent Weld	ASTM D 2235		
PVC Fittings	All	Solvent Weld	Solvent cement – ASTM D2564		

Appendix A: Maximum Design Pressures for Flanges Derated for Temperature Effects

For all design temperatures over 100°F the derating factor for ASME flanges shall be calculated in accordance with the requirements of ASME B16.5.

The following are maximum design pressures for a design temperature of 100°F and lower, and for the two maximum design temperatures shown in Tables 2 to 13.

Flange Material	Maximum Design Pressure (psig) @ 100°F & Lower Design Temperature					
	Sizes (NPS)	Class 150 PN 20	Class 300 PN 50	Class 400 PN 68	Class 600 PN 100	Class 900 PN 150
ASTM A105 or A350 LF2 Class 1	½ to 14	285	740	985	1480	2220
ASTM A182 Gr. F304	½ to 14	275	720	960	1440	2160
ASTM A182 Gr. F316	½ to 14	275	720	960	1440	2160
TES-FLGE-LD-US	16 to 48	285	740	990	1480	2220

Flange Material	Maximum Design Pressure (psig) @ 167°F Design Temperature					
	Sizes (NPS)	Class 150 PN 20	Class 300 PN 50	Class 400 PN 68	Class 600 PN 100	Class 900 PN 150
ASTM A105 or A350 LF2 Class 1	½ to 14	268	700	931	1400	2096
ASTM A182 Gr. F304	½ to 14	245	640	853	1279	1919
ASTM A182 Gr. F316	½ to 14	248	653	870	1306	1959
TES-FLGE-LD-US	16 to 48	285	740	990	1480	2220

Flange Material	Maximum Design Pressure (psig) @ 248°F Design Temperature					
	Sizes (NPS)	Class 150 PN 20	Class 300 PN 50	Class 400 PN 68	Class 600 PN 100	Class 900 PN 150
ASTM A105 or A350 LF2 Class 1 or MSS-SP-44	½ to 14	246	668	888	1336	2001
ASTM A182 Gr. F304	½ to 14	218	571	759	1140	1711
ASTM A182 Gr. F316	½ to 14	225	591	787	1182	1774
TES-FLGE-LD-US	16 to 48	285	740	990	1480	2220

Notes:

1. For design temperatures between those shown, calculate the maximum design pressure in accordance with the requirements of ASME B16.5. Do not interpolate between pressure classes.

Appendix B: Maximum Design Pressures of ASTM A106 Gr. B, API 5L Gr. B and ASTM A333 Gr. 6 (35,000 psi) Pipe

Maximum Design Pressures (psi)								
Nominal Size (NPS)	Schedule 40				Schedule 80			
	W.T.	Class 2	Class 3	Class 4	W.T	Class 2	Class 3	Class 4
¼	Schedule 40 not permitted for NPS 2 & under				**0.119**	9256	7713	6170
½					**0.147**	7350	6125	4900
¾					**0.154**	6160	5133	4107
1					**0.179**	5717	4764	3811
1¼					**0.191**	4833	4027	3222
1½					**0.200**	4421	3684	2947
2					**0.218**	3855	3213	2570
3	**0.216**	2592	2160	1728	**0.300**	3600	3000	2400
4	**0.237**	2212	1843	1475	**0.337**	3145	2621	2097
6	**0.280**	1775	1479	1183	**0.432**	2739	2282	1826
8	**0.322**	1568	1307	1045	**0.500**	2435	2029	1623
10	**0.365**	1426	1188	951	**0.594**	2321	1934	1547
12	**0.406**	1337	1115	892	**0.688**	2266	1889	1511
14	**0.438**	1314	1095	876	**0.750**	2250	1875	1500

Notes:

1. The calculations in the above table are based on ASME B31.8. Different maximum design pressures are applicable for the ASME B31.3 design code.
2. For Class 2, a design factor of 0.60 was used. A lower design factor applies to some Class 2 locations.
3. For Class 3, a design factor of 0.50 was used.
4. For Class 4, a design factor of 0.40 was used.

Appendix C: Maximum Design Pressures of ASTM A312 Gr. TP304/TP316 (30,000 psi) Pipe

Maximum Design Pressures (psi)								
Nominal Size (NPS)	Schedule 40				Schedule 80			
	W.T.	Class 2	Class 3	Class 4	W.T	Class 2	Class 3	Class 4
¼	Schedule 40 not permitted for NPS 2 & under				**0.119**	7933	6611	5289
½					**0.147**	6300	5250	4200
¾					**0.154**	5280	4400	3520
1					**0.179**	4900	4084	3267
1¼					**0.191**	4142	3452	2761
1½					**0.200**	3789	3158	2526
2					**0.218**	3304	2754	2203
3	**0.216**	2222	1851	1481	**0.300**	3086	2571	2057
4	**0.237**	1896	1580	1264	**0.337**	2696	2247	1797
6	**0.280**	1522	1268	1014	**0.432**	2347	1956	1565
8	**0.322**	1344	1120	896	**0.500**	2087	1739	1391
10	**0.365**	1222	1019	815	**0.594**	1989	1658	1326
12	**0.406**	1146	955	764	**0.688**	1943	1619	1295
14	**0.438**	1126	939	751	**0.750**	1929	1607	1286

Notes:

1. The calculations in the above table are based on ASME B31.8. Different maximum design pressures are applicable for the ASME B31.3 design code.
2. For Class 2, a design factor of 0.60 was used. A lower design factor applies to some Class 2 locations.
3. For Class 3, a design factor of 0.50 was used.
4. For Class 4, a design factor of 0.40 was used.

Appendix D: Maximum Pipe Diameter to Wall Thickness Ratios & Minimum Wall Thickness

Pipe Dia. (NPS)	D/t Ratio		Pipeline Min. W.T. (in)	Compressor Station Min. W.T. (in)
	EW	SAW		
3	28	-	0.126	0.217
4	36	-	0.126	0.236
6	53	-	0.126	0.280
8	55	-	0.157	0.323
10	57	-	0.189	0.366
12	68	-	0.189	0.406
14	67	-	0.209	0.437
16	73	73	0.220	0.500
20	91	91	0.220	0.500
24	95	95	0.252	0.500
30	-	104	0.287	0.500
36	-	111	0.323	0.500
42	-	119	0.354	0.500
48 and larger	-	119	0.402	0.500

Appendix E: Flange Bolting and Gaskets for NPS 14 and Smaller

Flange Size NPS	Flange Rating	Stud Dimensions			Gasket Dimensions	
		Diameter (in)	Length (in)	Qty/Flange	OD (in)	ID (in)
1	Class 150	0.500	2.50	4	2.64	1.26
	Class 300	0.625	3.00	4	2.87	1.26
	Class 600	0.625	3.50	4	2.87	1.26
	Class 900	0.875	5.00	4	3.15	1.26
1½	Class 150	0.500	2.75	4	3.39	2.13
	Class 300	0.750	3.50	4	3.74	2.13
	Class 600	0.750	4.25	4	3.74	2.13
	Class 900	1.000	5.50	4	3.90	2.13
2	Class 150	0.625	3.375	4	4.13	2.36
	Class 300	0.625	3.50	8	4.37	2.36
	Class 600	0.625	4.25	8	4.37	2.20
	Class 900	0.875	5.75	8	5.63	2.05
3	Class 150	0.625	3.50	4	5.39	3.50
	Class 300	0.750	4.25	8	587	3.50
	Class 600	0.750	5.00	8	587	3.19
	Class 900	0.875	5.75	8	6.61	3.19
4	Class 150	0.625	3.50	8	6.89	4.49
	Class 300	0.750	4.50	8	7.13	4.49
	Class 600	0.875	5.75	8	7.64	4.17
	Class 900	1.125	6.625	8	8.15	4.17
6	Class 150	0.750	4.00	8	8.74	6.61
	Class 300	0.750	4.75	12	9.88	6.61
	Class 600	1.000	6.625	12	10.51	6.18
	Class 900	1.125	7.625	12	11.38	6.18
8	Class 150	0.750	4.25	8	10.98	8.62
	Class 300	0.875	5.50	12	12.13	8.62
	Class 600	1.125	7.50	12	12.64	8.27
	Class 900	1.375	8.625	12	14.13	8.27
10	Class 150	0.875	4.50	12	13.39	10.75
	Class 300	1.000	6.25	16	14.25	10.75
	Class 600	1.250	8.50	16	15.75	10.24
	Class 900	1.375	9.25	16	17.13	10.24
12	Class 150	0.875	4.75	12	16.14	12.76
	Class 300	1.125	6.625	16	16.61	12.76
	Class 600	1.250	8.625	20	17.99	12.52
	Class 900	1.375	10.00	20	19.65	12.36
	Class 150	1.125	5.325	12	17.76	14.17

Flange Size NPS	Flange Rating	Stud Dimensions			Gasket Dimensions	
		Diameter (in)	Length (in)	Qty/Flange	OD (in)	ID (in)
14	Class 300	1.125	7.125	20	19.13	14.17
	Class 600	1.375	9.25	20	19.37	13.74
	Class 900	1.500	10.875	20	20.51	13.50

Appendix F: Flange Bolting and Gaskets for NPS 16 and Larger

Flange Size NPS	Flange Rating	Stud Dimensions			Gasket Dimensions	
		Diameter (in)	Length (in)	Qty/Flange	OD (in)	ID (in)
16	Class 600	1.50	12.00	20	22.24	15.75
	Class 900	1.625	13.50	20	22.64	15.51
18	Class 600	1.875	12.75	20	24.13	17.68
	Class 900	1.875	15.50	20	25.12	17.52
20	Class 600	1.625	13.50	24	26.89	19.69
	Class 900	2.00	16.50	20	27.52	19.49
24	Class 600	1.875	15.50	24	31.14	23.74
	Class 900	2.50	20.75	20	32.99	23.74
30	Class 600	2.00	17.00	28	38.27	29.76
	Class 900	3.00	23.50	20	39.76	30.51
36	Class 600	2.50	19.50	28	44.49	36.14
	Class 900	3.50	26.75	20	47.24	36.26
42	Class 600	2.50	23.00	28	47.99	42.01
	Class 900	3.50	29.50	24	51.26	43.74
48	Class 600	2.75	25.50	32	54.76	47.99
	Class 900	4.00	33.50	24	58.50	50.00

Note:

1. Bolt lengths for flange sizes NPS 16 to 48 include allowance to accommodate hydraulic tensioning. Class 600 and Class 900 gaskets for sizes NPS 2 to 48 are spiral wound type with inner and external ring.

- END OF DOCUMENT -

PURPOSE

This Specification provides Company requirements for the qualification, manufacture, inspection, and testing of pressure containing equipment components.

SCOPE / APPLICABILITY

This Specification includes specific materials requirements and is intended for use in conjunction with, and as a supplement to, the applicable pressure containing equipment specifications.

This Specification applies to equipment components designed to match CSA Z245.1 Grade 241 through Grade 550 (API 5L Grade B and Grades X42 through X80) pipe, such as pressure containing measurement devices, control valves, pressure relief valves, and regulators.

This Specification applies to pressure containing equipment components intended for installation in non-sour natural gas and non-sour liquid hydrocarbon pipeline systems NPS 4 or greater.

The Responsible Engineer shall be contacted for clarification if needed.

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1 GENERAL

This Specification is intended for use in conjunction with, and as a supplement to, the applicable pressure containing equipment specifications and provides materials requirements additional to those specifications.

All pressure-containing equipment components shall conform to the following requirements:

- The manufacturer shall supply the Company, at the time of quotation, any exceptions or alternatives to the requirements outlined in this specification. Items covered by technical agreements need not be addressed at the time of quotation since the technical agreements apply to each order.

2 DESIGN REQUIREMENTS

The following requirements apply to the design of pressure-containing equipment components.

2.1 End flanges

The following design requirements apply to end flanges that are part of the equipment:

- End flanges shall be weld neck or integrally cast/forged flanges with a raised face for pressure class PN 150 (ASME Class 900) or lower.
- End flanges shall have ring joint facing for pressure classes higher than PN 150 (ASME Class 900).

2.2 Field Weld Ends

The following design requirements apply to field weld ends:

- Field weld ends shall be bevelled in accordance with CSA Z662, Fig. 7.1; ASME B31.4, Fig. 434.8.6-1; or ASME B31.8, Appendix I, Figure I-4.
- The specified minimum yield strength (SMYS) of equipment components used for field weld ends shall preferably be equal to or greater than that of the matching pipe.
- In no case shall the SMYS of the equipment component used for field weld ends be less than 2/3 of that of the matching pipe.

3 MATERIALS REQUIREMENTS

Unless a different temperature is specified on the request for quote or purchase order:

- all materials shall be suitable for service at the minimum design temperature of -45°C (-50°F), and shall meet the requirements of this Specification
- all materials shall be suitable for exposure to sweet natural gas, containing by-products of processing and treating natural gas, or sweet hydrocarbon liquids.

3.1 Materials for Bolting for Equipment

Bolting used for pressure retention purposes shall be manufactured in accordance with the requirements of ASTM A194 Gr. 4 or Gr. 7, or ASTM A320 Gr. L7 or L7M.

3.2 Materials for Equipment Components Other Than Bolting

Materials selected for equipment components other than bolting shall be submitted for review and written acceptance by the Company prior to manufacture.

3.2.1 Heat Treatment of Test Specimens

Test specimens for mechanical tests shall be given the same heat treatment as the part they represent.

For equipment components that have been tempered or stress-relieved, the component need not be retested after any subsequent re-heat treatment operation is performed provided that the subsequent re-heat treatment is performed at or below the temperature of the original temper or stress relief operation.

3.2.2 Carbon Equivalent

For NPS 16 and larger equipment, a product analysis shall be conducted for each heat of material to be used for field weld ends. The sample shall be analyzed for carbon, manganese, phosphorous, sulphur, silicon, chromium, molybdenum, vanadium, copper, and nickel.

It shall be permissible to take material for the product analysis from the test coupon that is used for the mechanical tests for the same heat of steel or from a casting or forging from the same heat of steel.

For NPS 16 and larger equipment, the carbon equivalent (C.E.) shall be calculated for each heat of material to be used for field weld ends. The carbon equivalent shall not exceed 0.50 as calculated using the following equation:

$$C.E. = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

3.3 Notch Toughness

All carbon steel equipment components shall be Charpy V-notch tested in accordance with the requirements of ASTM A370, except:

- equipment components less than NPS 4
- bolting material 12.7 mm (1/2 in) and less in diameter
- nuts of any size
- equipment components manufactured from austenitic stainless steel

3.3.1 Test Specimen

Charpy V-notch tests shall be performed on the largest practical specimen size.

- The minimum average energy absorption value for any test shall be 27 J (20 ft·lb) based on full-size specimens.
- Where sub-size specimens must be used, the minimum energy absorption requirement shall be 27 J (20 ft·lb) multiplied by the ratio of the specimen width to 10 mm (0.394 in).

3.3.2 Test Temperature

Tests shall be performed at -45°C (-50°F) unless a different temperature is specified on the request for quote or purchase order. Materials tested at lower temperatures than specified shall be acceptable if the specified absorbed energy value is met at the lower test temperature.

4 PREPRODUCTION REQUIREMENTS

The Company shall supply the manufacturer with a request for quote and purchase order describing the operating conditions for which the equipment components are intended.

Prior to the commencement of production, the Manufacturer shall submit, or have previously submitted, to the Company the documents in Table 4-1 and shall have received written acceptance from the Company unless otherwise specified. The Manufacturer shall inform the Company in writing of any changes to the documents and shall obtain the written acceptance of the Company for such changes.

Table 4-1: Preproduction Documentation Requirements

Item	Requirements
Copy of quality program	See Section 5.1
Copy of the quality program registration certificate	See Section 5.1
List of materials	Materials for each equipment component (see Section 3.2).
Welding procedures	See Section 2.4.2
Pressure test procedure	See Section 2.5
Definition of critical sections	See Section 7.1.1
Drawings	Drawings shall include: • Outline dimensions • Weld end dimensions • Welding procedure and revision numbers to be used for welds (see Section 5.2) • Serial Number • Bill of Materials for equipment components, including material designations • Traceability numbers

Item	Requirements
	• Purchase order number • The Company material number • The Company specification and revision date

5 MANUFACTURING REQUIREMENTS

The following requirements apply to the manufacturer and manufacturing process.

5.1 Quality Program

The manufacturer shall have and adhere to a documented quality program accepted in writing by the Company prior to production (e.g., ISO 9001). The quality program shall be registered with an independent registrar.

5.2 Welding Qualification

Welding procedures for the following welds shall be submitted for review and written acceptance by the Company prior to use:

- Type 1: Pressure-containing fabrication welds
- Type 2: Welds defined by the Company as critical
- Type 3: Weld repairs to the welds defined in type 1 and 2
- Type 4: Weld repairs to cast equipment components that will be used on NPS 16 and larger equipment

The following weld procedure requirements apply to the four weld types defined above:

- Welds shall be made using welders and welding procedures qualified in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section IX.
- Welding procedure qualifications shall include impact testing in the weld and heat-affected zone and the requirements of Section 3.3.1 shall be met.
- Specimen quantity, location, and orientation shall be in accordance with the requirements of Paragraphs UG-84(g) and UG-84(h)(3) of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
- Welding procedures shall include micro-hardness traverses across the weld, heat-affected zones, and parent metal. The micro-hardness tests shall be performed in accordance with the requirements of ASTM Standard E384. The maximum hardness shall be 350 HV using a load of 1000 g or less.

  Note: For Type 4 welds, this is only required for welds that are not heat-treated.

Welds not defined above shall be made using welders and welding procedures qualified in accordance with the requirements of the applicable material specification or ASME Boiler and Pressure Vessel Code, Section IX.

Where cast equipment components are obtained from a sub-vendor, the equipment manufacturer shall be responsible for obtaining the required weld repair procedures.

5.3 Plant Access

While work on the contract is being performed, the Company or its representative shall have free entry at all reasonable times to all parts of the Manufacturer's facilities involved in the production of the end closures ordered. All reasonable facilities shall be provided to the Company or its representative to satisfy that the product is being furnished in accordance with this Specification, related specifications, and the purchase order.

5.4 Painting and Coating

All equipment shall be painted/coated in accordance with TES-COAT-P1 Paint Systems for Above Ground Facilities Specification (CND-US-MEX) (EDMS No. 3694704) for the installation locations as specified in the request for quote and purchase order.

6 PRESSURE AND OPERATIONAL TEST REQUIREMENTS

All equipment ordered to this Specification shall be subjected to a shell hydrostatic pressure test. There shall be no leakage for the duration of the pressure test and no permanent distortion as a result of the pressure test.

The written pressure test procedures shall be submitted for review and written acceptance by the Company prior to use. The last portion of the shell test shall be conducted in the presence of the Company's representative unless otherwise agreed in writing by the Company.

Continuous recording charts demonstrating test pressures, temperatures, and durations shall be provided for tests with a duration of one hour or longer. Where continuous recording charts are not required, the minimum test duration and minimum test pressure achieved shall be reported.

- The test charts and test records shall be certified by the manufacturer and submitted to the Company in accordance with the requirements of Section 4.
- The minimum shell test duration shall be in accordance with the requirements in Table 6-1.
- The minimum shell test pressure shall be 1.5 times the rated cold working pressure.

Table 6-1: Minimum Shell Test Duration by Component Size

Nominal Component Size	Minimum Test Durations (minutes)	
	Shell Test – Cast Items	Shell Test – Fabricated or Wrought Items
NPS 2 to NPS 4 incl.	15	5
NPS 6 to NPS 10 incl,	30	15
NPS 12 to NPS 14 incl,	30	15

Nominal Component Size	Minimum Test Durations (minutes)	
	Shell Test – Cast Items	Shell Test – Fabricated or Wrought Items
NPS 16 to NPS 18 incl.	120	30
NPS 20 to NPS 36 Incl.	240	60
Larger than NPS 36	240	120

6.1 Operational Tests

Operational testing shall be as specified in the applicable equipment specification.

7 INSPECTION REQUIREMENTS

All tests and inspections required by this specification shall be performed in the Manufacturer's plant prior to shipment. Tests and inspections shall be conducted to cause no undue interference with the operations of the Manufacturer's plant. The Company reserves the right to witness any test but it does not constitute a hold point unless explicitly identified.

Third party inspection requirements only apply for a nominal size of NPS 16 and larger unless otherwise specified on the purchase order.

7.1 Nondestructive Examination (NDE)

The following requirements apply to NDE of pressure-containing castings and welds, as well as reporting NDE results.

7.1.1 Cast Equipment Components

All castings for NPS 16 and larger equipment shall be fully inspected by magnetic particle examination in accordance with the requirements of MSS SP-53.

Critical sections of pressure-containing cast components shall be defined by the Manufacturer and accepted in writing by the Company.

Critical sections and weld repairs to critical sections of cast components used on NPS 16 and larger equipment shall be inspected by film radiography, in accordance with the requirements of MSS SP-54 or in accordance with a Company accepted ultrasonic inspection procedure.

7.1.2 Welds

All NDE conducted shall meet the requirements of the applicable paragraph or appendix of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 shown below:

- Radiographic inspection: Paragraph UW51
- Ultrasonic inspection: Appendix 12
- Magnetic particle inspection: Appendix 6
- Liquid penetrant inspection: Appendix 8

Table 7-1 outlines the acceptable NDE methods for use on different weld types.

Table 7-1: Acceptable NDE Method by Weld Type

Weld Type		Acceptable NDE Methods	
		Radiographic or Ultrasonic Inspection	Magnetic Particle or Liquid Penetrant Inspection
1	Pressure-containing fabrication welds.	✓	-
2	Welds defined by the Company as critical.	✓	-
3	Weld repairs to weld types 1 and 2.	✓	-
4	Major weld repairs to pressure containing parts on NPS 16 and larger equipment components.	✓	-
6	Welds joining a component smaller than NPS 2 to a pressure-containing part.	-	✓
7	Welds joining a non-pressure-containing part to a pressure-containing part (e.g., lifting lugs).	-	✓

7.1.3 Reporting

All radiographs for pressure-containing fabrication welds and for repairs to such welds shall be identified and shall be available for the Company's representative to view.

A written record of all nondestructive inspection results required by Section 7.1.1 and 7.1.2 shall be prepared and certified by the manufacturer for submission to the Company in accordance with the requirements of Section 9.

7.2 Defect Criteria and Repair of Defects

Equipment components containing defects shall be addressed through one of the following approaches:

- The defect shall be removed, provided that the remaining wall thickness is within the limits specified in the applicable material specification.
- The defect shall be removed and the component repaired by welding, provided that:
  - The qualification of the welders and welding procedures is in accordance with the requirements of Section 5.2.
  - The weld repair is inspected in accordance with the requirements of Section 7.1.
  - All major weld repairs to equipment components that will be used on NPS 16 and larger equipment shall be heat-treated.
- The component shall be rejected.

8 MARKING REQUIREMENTS

Equipment shall have stainless steel nameplates marked with the following information as a minimum:

- Equipment Manufacturer's identification,
- Nominal size and total weight,
- Pressure class if applicable,
- Internal diameter,
- Minimum design temperature in degrees Celsius (degrees Fahrenheit),
- Traceability numbers,
- Body design code, flange design code and field weld end material,
- Positive flow direction if applicable,
- Operating pressure and temperature range,
- Maximum and minimum actual (at flowing conditions) volumetric flow rate per hour if applicable, and
- Purchase order number.

Additional markings shall be as per the applicable equipment specification.

Additional markings desired by the manufacturer are permitted. However, information on interpreting these additional markings shall be provided to the Purchaser.

9 CERTIFICATION PACKAGE

The manufacturer shall supply to the Company, prior to shipping the equipment, reports and test certificates correlated to the equipment serial number and the traceability number.

The reports and test certificates shall contain the following information:

- Product analysis and carbon equivalent of field weld ends of NPS 16 and larger equipment.
- Mechanical and chemical test results for each equipment component, including the mating flange if one is required.
- Certificate of compliance for bolting for equipment.
- Certificate of compliance for bolting supplied to attach the mating flange to the equipment, where such bolting is required.
- Test records from pressure tests.
- A written record of all nondestructive inspection results required by Section 7.1 shall be prepared and certified by the manufacturer for submission to the Company.

These records shall identify the procedure number and revision level used for the inspection.

- Confirmation that the equipment has been manufactured in accordance with the requirements of this Specification.
- Purchase order number.
- Make of equipment.
- Model.
- Serial number.
- Traceability number.
- Equipment size.
- A copy of the Company accepted drawing.
- Identification of the welding procedures and revision numbers used.

10 GLOSSARY

Terms and definitions related to this Specification can be found in APPENDIX A.

11 REFERENCES

This document relies on a number of references to legislation (act, statutes, and regulations), certificates, and orders and may include directives, guidelines, standards, and codes to the extent they contain legally binding requirements for TransCanada.

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 11-1.

Table 11-1: External and Internal References

Document No.	Title
Legal Requirements	
NEB OPR SOR/99-294	National Energy Board Onshore Pipeline Regulations (NEB OPR)
Various	Applicable Provincial Regulations for Provincially Regulated Systems
49 CFR 192	Code of Federal Regulations, Title 49 Part 192, Transportation of Natural Gas and Other Gas by Pipeline: Minimum Federal Safety Standard
49 CFR 195	Code of Federal Regulations, Title 49 Part 195, Transportation of Hazardous Liquids by Pipeline: Minimum Federal Safety Standard
NOM-007-SECRE	Transporte de Gas Natural (Where applicable)
Industry Codes and Standards	

Document No.	Title
CSA Z662	Canadian Standards Association (CSA) Oil and Gas Pipeline Systems
CSA Z245.12	Steel Flanges
CSA Z245.15	Steel Valves
ASME B31.3	American Society of Mechanical Engineers (ASME) Process Piping
ASME B31.4	Pipeline Transportation Systems for Liquids and Slurries
ASME B31.8	Gas Transmission and Distribution Piping Systems
ASME B16.5	Pipe Flange and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard
ASME B16.34	Valves — Flanged, Threaded, and Welding End
ASME B16.47	Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard
ASME BPVC-VIII	ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Rules for Construction of Pressure Vessels
ASME BPVC-IX	ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications
ASTM A216	American Society for Testing and Materials (ASTM) Standard Specification for Steel Casting, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A350	Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components
ASTM A352	Standard Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service
ASTM A516	Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A194	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A320	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service
ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM E384	Standard Test Method for Knoop and Vickers Hardness of Materials
ISO 9001	Quality management systems – Requirements

Document No.	Title
MSS SP-53	Manufacturers Standardization Society (MSS) Quality Standard for Steel Castings and Forgings for Valves, Flanges and Fittings and Other Piping Components - Magnetic Particle Exam Method
MSS SP-54	Quality Standard for Steel Castings for Valves, Flanges, and Fittings and Other Piping Components - Radiographic Examination Method
Internal References – Documents that Reference this Specification	
N/A	N/A
Internal References – Documents Referenced by this Specification	
EDMS No. 3694704	TES-COAT-P1 Paint Systems for Above Ground Facilities Specification (CDN-US-MEX)

12 DOCUMENT HISTORY

Rev.		
01	Description	Effective Date
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	Responsible Engineer
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Derek Chen, P. Eng.
	Impact Assessment Summary	Document Owner
	This specification was revised to streamline the documentation required for the Materials Engineering group and to make it more easily accessible to those who use it.	Derek Chen, P. Eng.

13 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A.
Industry Standards	
N/A	N/A.
General	
N/A	This Specification was updated and put into the new template.

14 APPROVALS

APPROVALS		
Originator: Cindy Guan, P. Eng. Welding and Materials Engineering	Cindy Guan Signature	Oct 31, 2016 Date
Reviewer: Sandra Kleinsasser. EIT Welding and Materials Engineering	Sandra Kleinsasser Signature	Oct. 31, 2016 Date
Responsible Engineer: Derek Chen, P. Eng. Welding and Materials Engineering	Derek Chen Signature Oct 31, 2016 Date	PROFESSIONAL ENGINEER ALBERTA (DEREK) CHEN Oct 31, 2016 APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, Manager Welding and Materials Engineering	James Ferguson Signature	Nov. 1, 2016 Date

APPENDIX A TERMS AND DEFINITIONS

Terms	Definitions
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Material
Bolting	Bolts, studs, cap screws, and nuts
CFR	Code of Federal Regulations
Company or Purchaser	TransCanada PipeLines Limited, its corporate affiliate, or its agent
CSA	Canadian Standards Association
DOT	United States Department of Transportation
Equipment component	A pressure containing part used in the manufacture of a specific piece of equipment, i.e., measurement devices, control valves, pressure relief valves, and regulators, etc.
Heat treatment	One or more of the following methods: • Stress relieving • Normalizing • Normalizing and tempering • Quenching and tempering
ISO	International Organization for Standardization
Major weld repair	One or more of the following in the parent metal of casting: • A weld repair that is made to correct leakage: • When the depth of the cavity prepared for welding exceeds 20% of the actual wall thickness or 1 inch, whichever is smaller. • When the area of the cavity prepared for welding exceeds 10 sq in. / 65 square cm
Manufacturer or Vendor	Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.
Material Number	The number assigned to each item on a purchase order (also known as part

Terms	Definitions
	number, catalogue number, SAP number or material master number).
MSS	Manufacturers Standardization Society
NEB	National Energy Board
NOM	Norma Oficial Mexicana
Pressure-Containing Parts	Components designed to contain the fluid being transported in the pipeline system
Purchase order	The purchasing document used to purchase the specified item(s)
Regulatory Authority	The national and/or local regulator having jurisdiction over the facility.
Technical Agreement	The document signed by the Company and the manufacturer, which states a mutual agreement on a technical matter.
Traceability Number	A number that will be marked on the specified item(s) to allow identification of each piece. It shall consist of the letters PO, the purchase order number, the purchase order line item number, and where applicable, a numerical suffix. The numerical suffix is only required when more than one piece is supplied for the same item number on the same purchase order.
Welding Procedure	The Welding Procedure Specification, Procedure Qualification Record, and all associated non-destructive and destructive test data

PURPOSE

This Specification outlines the requirements for the materials, qualification, manufacture, testing and inspection of carbon steel valves for gas service.

SCOPE/APPLICABILITY

This Specification applies to carbon steel ball, check, gate and plug valves intended for installation in the Company's non-sour natural gas onshore pipeline systems in Canada, the United States (U.S.), and Mexico.

This Specification applies to carbon steel valves with a nominal diameter of 406.4 mm (NPS 16) and larger with a pressure class of PN 20 (ASME 150) and higher. At the Company's discretion, this Specification may be applied in whole or in part to valve sizes not specifically addressed in this Specification.

This Specification is to be used in conjunction with API Specification 6D, latest revision, and covers additional requirements to those specified in API 6D, CSA Z245.15, latest revision, and any amendment, supplement or errata issued by API or CSA.

The headings and numbering in this Specification correspond to those in API 6D. Where no incremental requirements are given in this Specification, API 6D shall apply as written. If conflict exists between this Specification and the requirements in API 6D, the more stringent of the requirements shall apply.

The Responsible Engineer shall be contacted for clarification, if needed.

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GLOSSARY

ASME

American Society of Mechanical Engineers

ASTM

American Society for Testing and Material

Bi-directional seats

A seat design where each seat must seal in both directions at all pressures, up to the rated pressure. This feature is sometimes referred to as “double piston effect”.

Bolting

Bolts, studs, cap screws and nuts.

Certificate of compliance

A document that states that the product was manufactured, sampled, tested and inspected in accordance with the applicable specification and the purchase order, and was found to have met such requirements. Bolting and pressure containing parts smaller than 60.3 mm (NPS 2) shall be furnished with a certificate of compliance or Material test report (MTR). MTRs shall be supplied for components 60.3 mm (NPS 2) and larger.

CFR

Code of Federal Regulations

Company or Purchaser

TransCanada PipeLines Limited, its corporate affiliate, or its agent.

CSA

Canadian Standards Association

Double block and bleed

A valve with two seating surfaces that, in the closed and open position, provides a seal against pressure from both ends of the valve with a means of venting/bleeding the cavity between the seating surfaces. The body cavity must be capable of being bled down to atmospheric pressure when the valve is in the fully open and fully closed positions.

Note:

This supersedes the definition in API 6D Para. 3.1.10.

Double isolation and bleed valve (DIB)

A valve with two bi-directional seating surfaces that, in the closed and open position, provides a seal against pressure from both ends of the valve and from the body

cavity of the valve, and a means of venting/bleeding the pressure between the seating surfaces. This design is also referred to in API 6D as “DIB-1”.

DOT

United States Department of Transportation

Equipment component

A pressure containing part used in the manufacture of a specific piece of equipment (i.e., measurement devices, control valves, pressure relief valves and regulators, etc.).

Heat treatment

One or more of the following methods:

- stress relieving
- normalizing
- normalizing and tempering
- quenching and tempering

ISO

International Organization for Standardization

Major weld repair

One or more of the following in the parent metal of a casting:

- a weld repair that is made to correct leakage
- when the depth of the cavity prepared for welding exceeds 20% of the actual wall thickness or 25.4mm (1 in.), whichever is smaller
- when the area of the cavity prepared for welding exceeds 64.52 sq. cm (10 sq. in.)

Manufacturer or Vendor

Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.

Material number

The number assigned to each item on a purchase order (also known as part number, catalogue number, SAP number or material master).

MSS

Manufacturer Standardization Society

NEB

National Energy Board

NOM

Norma Oficial Mexicana

Pressure-containing parts

Components designed to contain the fluid being transported in the pipeline system.

Purchase order

The purchasing document used to purchase the specified item(s).

Regulatory Authority

The national and/or local regulator having jurisdiction over the facility.

Technical Agreement

The document signed by the Company and the Manufacturer that states a mutual agreement on a technical matter.

Traceability number

A number that will be marked on the specified item(s) to allow identification of each piece. It shall consist of the letters PO, the purchase order number, the purchase order line item number, and where applicable, a numerical suffix. The numerical suffix is only required when more than one piece is supplied for the same item number on the same purchase order.

Welding Procedure

The Welding Procedure Specification, Procedure Qualification Record and all associated non-destructive and destructive test data.

1 SCOPE

1.1 General

1.1.1 Valves purchased for the U.S. and Mexico shall be certified as API. Valves purchased for Canada shall be certified as CSA and may be dual-certified as both API and CSA. Certification shall consist of a Manufacturer-issued certificate of compliance.

1.1.2 Valves supplied according to this Specification shall comply with the applicable technical agreement and meet any additional requirements in the request for quote and/or purchase order description.

1.3 Conformance with Specification

1.3.1 The Manufacturer shall have a documented Quality Program that is registered with an independent registrar.

1.5 Notch Toughness

1.5.1 All pressure containing components in valves shall have proven notch toughness properties at the minimum design metal temperature (MDMT) specified on the request for quote and/or purchase order.

1.6 Inspection and Test Plan (ITP)

1.6.1 Unless otherwise stated on the purchase order, the Manufacturer shall prepare and submit an inspection and test plan (ITP) conforming to the requirements of this Specification. The ITP shall list the applicable manufacturing procedures to be applied, inspection points and requirements, and the applicable acceptance criteria. The ITP requires approval by the Company prior to the commencement of manufacturing.

2 NORMATIVE REFERENCES

2.1 The Specifications and Standards listed in Section 16 shall apply in addition to those listed in API 6D.

4 VALVE TYPES AND CONFIGURATIONS

4.1 Valve Types

4.1.1 Gate Valves

4.1.1.1 Gate valves shall be of the through conduit type (round-port full-bore, slab or expanding) as specified in the request for quote and/or purchase order description.

4.1.1.2 Gate valves shall be rising stem and include a body drain valve at or near the bottom of the valve body.

4.1.1.3 Slab gate valves shall be bolted bonnet, double block and bleed, with upstream self-relieving seats. Seats shall be equipped with soft seat inserts and the seat rings shall be field removable/replaceable.

4.1.1.4 Through conduit gate valves shall have a secondary seat sealing system capable of correcting leaks at the rated working pressure of the valve.

4.1.1.5 All gate valves shall have a secondary stem sealing system capable of correcting leaks at the rated working pressure of the valve. The stem seal shall be of a type that can be hydraulically energized, such as a stacked chevron, U-cup style or other multi-component seals approved by the Company. Mechanically energized seals are also permitted.

4.1.1.6 Primary stem seal leak indicator fittings (i.e., tattletale fittings) are not permitted. Taps used for this purpose shall be sealed with a solid pipe plug.

4.1.2 Lubricated and Non-Lubricated Plug Valves

4.1.2.1 Plug valves shall be lubricated, pressure balanced and inverted taper. The lubricant used shall resist dissolving, gumming or chemical change under the service conditions specified.

4.1.2.2 Plug valves shall be manufactured with a secondary stem sealant system capable of correcting leaks at the rated working pressure of the valve. A sealant system that energizes the stem packing shall be acceptable.

4.1.2.3 Plug valves must be suitable for installation with the valve stems positioned either vertically or horizontally.

4.1.3 Ball Valves

4.1.3.1 Ball valves shall be either a full opening or reduced opening configuration, as specified on the request for quote and/or purchase order.

4.1.3.2 Ball valves shall be double isolation and bleed with two bi-directional seats (i.e., DIB-1).

4.1.3.3 Ball valves shall have a secondary seat and stem sealing system capable of correcting leaks at the rated working pressure of the valve. Primary stem seal leak indicator fittings (i.e. tattletale fittings) are not permitted. Taps used for this purpose shall be sealed with a solid pipe plug.

4.1.3.4 Ball valves must be suitable for installation with the valve stems positioned from vertical up to horizontal.

4.1.3.5 The body cavity must be capable of being bled down to atmospheric pressure when the valve is in the fully opened or closed position.

4.1.4 Check Valves

4.1.4.1 Check valves shall be regular swing type, full-opening swing type, or axial flow as specified in the request for quote and/or purchase order description.

4.1.4.2 Swing type check valves shall be equipped with a vent fitting to safely enable depressurization of the valve downstream of the clapper.

4.1.4.3 Check valves shall be designed and manufactured so that, when installed, the valves are in the closed position when at rest.

5 DESIGN

5.2 Pressure and Temperature Rating

5.2.1 For valves certified as CSA only, the pressure-temperature ratings in CSA shall apply. API valves shall comply with the pressure-temperature rating requirements of API 6D. Dual-certified valves shall comply with the pressure-temperature rating requirements of CSA for valves installed in Canada, and shall comply with the pressure temperature rating requirements of API 6D for valves installed in the U.S. or Mexico.

5.2.2 The ratings specified in Clause 5.2.1 of this Specification shall not apply to non-metallic resilient sealing or plastic sealing materials. Such materials shall be capable of withstanding the rated pressure over the temperature range specified by the Company.

5.5 Valve Operation

5.5.1 The data as listed in Clause 5.5 of API 6D shall be provided for all valves at the time of quotation except that the flow coefficient is not required for full-opening valves.

5.7 Valve Ends

5.7.1 Flanged Ends

5.7.1.1 General

5.7.1.1.1 Flanges for pressure classes PN 150 (ASME 900) and lower shall be raised face unless otherwise specified. Flanges in accordance with the requirements of CSA Standard Z245.12 shall also be acceptable.

5.7.1.1.2 End flanges shall be weld neck or integrally cast or forged flanges, provided that the design stresses are no greater than in an equivalent weld neck flange and that the flange dimensions necessary for fit-up (e.g., bolt circle diameter, bolt hole size) comply with the requirements of this Specification.

5.7.2 Welding Ends

5.7.2.1 If pipe pups are required, Engineering shall be engaged for welding ends with pipe pups (length, wall thickness and grade of pups, and wall thickness/grade of associated piping to be discussed between the Company and the Manufacturer).

5.7.2.2 The weld end of the valve shall meet the calculated inside diameter based on the specified matching pipe diameter and thickness ± 1.0 mm (± 0.04 in.). The weld end may be back beveled to meet the inside diameter requirement.

5.7.2.3 For 457 mm (NPS 18) or smaller valves, the minimum acceptable wall thickness at the weld bevel shall be 87.5% of t_D. For valves larger than 457 mm (NPS 18), the minimum acceptable wall thickness at the weld bevel shall be 92% of t_D.

Note:

t_D is the design wall thickness at the weld bevel.

5.7.2.4 The weld end of the valve shall meet the following requirements:

$$t_D \leq 1.5\ t$$

$$S_1 \leq 1.5\ S_2$$

Where:

t = specified wall thickness of matching pipe (mm/in.)

t_D = design thickness of the weld end (mm/in.)

S_1 = specified minimum yield strength of pipe (kPa/ psi)

S_2 = specified minimum yield strength of valve end (kPa/ psi)

5.8 Valve Cavity Pressure Relief

5.8.1 Valve body cavity pressure relief devices that relieve to atmosphere are prohibited.

5.9 Drains

5.9.1 For valves other than check and plug valves, at least one drain connection shall be supplied on the bottom portion. On below ground valves, connections to the valve body shall be in accordance with Clause 5.24 of this Specification.

5.10 Injection Points

5.10.1 The seat and stem sealant fittings shall be the “Flow Wolf” from Sealweld Corporation Ltd., or other Company-approved products with a one-piece body design and a threaded cage. The fitting's external thread shall be standard NPT.

5.10.2 The seat lubricating port shall be protected by a ball check device independent of the lubricating fitting to provide for safe removal or replacement of the fitting when a valve is under line pressure conditions. The ball check shall be “Flow Wolf” from Sealweld Corp., unless otherwise agreed.

5.10.3 The number and location of the seat fittings shall provide proper distribution and sufficient deposition of the sealant.

5.11 Drain, Vent and Sealant Lines

5.11.1 Drain valves for aboveground valves shall be lockable full port FNPT X FNPT ball valves with a minimum rating as shown in Table 5-2, attached to the line valve with a schedule 160 pipe nipple and plugged with a solid pipe plug. Ball valves shall be the same make/model as specified in Table 5-3 of this Specification, unless otherwise agreed. Where two or more drain or vent taps are supplied on the valve, one shall be equipped with the previously described ball valve and the remaining taps shall each be solid with a solid pipe plug, unless otherwise specified in the purchase order or datasheet. The size of the drain connections shall be in accordance with the requirements of Clause 5.11.4 of this Specification.

5.11.2 On below ground valves, the requirements of Clause 5.24 of this Specification shall be incorporated.

5.11.3 Drain piping shall be sized as per Table 5-1, except for swing check valves, which require that the drain only be 21.3 mm (NPS ½).

5.11.4 Sealant extension lines and fittings shall be 21.3 mm (NPS ½) and the stem sealant line shall be identified with a tag.

Table 5-1: Minimum Body Drain Piping Size by Valve Size

Valve Size	Minimum Body Drain Piping Size
610 mm (NPS 24) and smaller	33.4 mm (NPS 1)
Larger than 610 mm (NPS 24)	48.3 mm (NPS 1 ½)

5.13 Handwheels and Wrenches – Levers

5.13.1 Where handwheels are supplied, they shall turn clockwise to close the valve. The open and closed positions shall be labeled. An arrow to indicate the position shall be supplied by the Manufacturer.

5.14 Locking Provision

5.14.1 Manually operated valves shall be supplied with locking devices.

5.16 Position Indicators

5.16.1 All valves supplied with manual actuation (e.g., gearboxes) shall be furnished with a position indicator, clearly indicating full open and closed position of the obturator.

5.18 Actuator, Operators and Stem Extensions

5.18.6 A pressure relieving device (or spring-loaded vent) with a weatherproof cover shall be provided in a ½ in. NPT minimum size opening located approximately 150 mm (6 in.) below the top of the extension housing. The design shall be accepted in writing by the Company.

5.18.7 The inside of the valve yoke, the inside of the extension housing and the outside of the torque tube shall be cleaned free of mill scale and treated with a rust inhibitor.

5.18.8 The mounting flange joining the stem extension to the valve stem shall be furnished with a gasket or O-ring designed to prevent water from entering the joint between the stem and the extension.

5.18.9 Installation instructions for mounting the stem extensions shall be provided by the Manufacturer to the Company. The instructions shall include provisions for installing the extension during valve assembly fabrication. This shall include installation with the stem in the horizontal position. This submittal shall form part of the pre-production documentation requirements.

5.19 Lifting

5.19.1 Lifting lugs shall be designed to lift at least 1.5 times the nominal weight of the valve to withstand stresses from lifting the valve and the expected weight of a power

actuator. Lifting lugs fabricated by cutting shall have the cut surfaces ground or machined to remove possible stress concentrators.

5.20 Drive Trains

5.20.4 Valve stem keys and gear set input shaft keys shall be secured in the keyway by mechanical means.

5.24 Ancillary Connections

5.24.1 Sealant injection connections to the valve body shall consist of a forged extension piece one size larger than the applicable piping and with a thickness of at least XXS. The extension piece shall be welded to the valve body using a full penetration or socket weld. Socket weld dimensions shall comply with ASME B16.11. The end of the extension piece shall have a female threaded connection fitted with a solid hex plug. The ancillary connection shall exit perpendicular to the extension piece and shall be a female threaded connection (see Figure 5-1 of this Specification).

5.24.2 Drain connections to the valve body shall be as described in Clause 5.24.1 of this Specification, except that the end of the extension piece may be solid (i.e., no female thread or hex plug required).

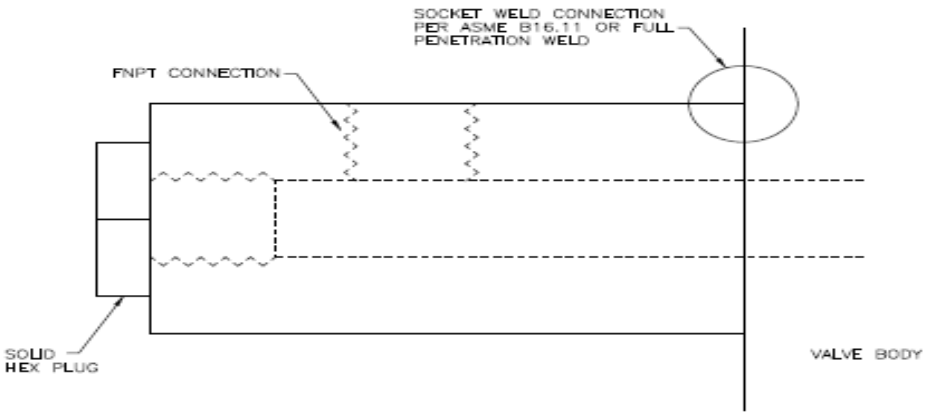

Figure 5-1: Ancillary Connections

5.25 Ancillary Piping (Sealant, Vent and Drain Piping)

5.25.1 Where necessary, ancillary piping shall be extended to a convenient and accessible location. Ancillary piping shall be capable of withstanding the maximum rated pressure at the minimum design temperature. The sealant, vent and drain pipe shall be ASTM A106 seamless pipe at a minimum. The schedule and pressure rating of the piping shall be as shown in Table 5-2.

Table 5-2: Schedule and Pressure Rating of Ancillary Piping and Valves

	PN 100 (ASME 600) and lower		PN 150 (ASME 900)		PN 250 (ASME 1500)	
	Sealant Lines	**Drain Lines**	**Sealant Lines**	**Drain Lines**	**Sealant Lines**	**Drain Lines**
Pipe	Schedule 160	Schedule 80	Schedule 160	Schedule 80	Schedule 160	Schedule 160
Threaded Nipples	Schedule 160	Schedule 160	Schedule 160	Schedule 160	Schedule 160	Schedule 160
Fittings	Class 6000 minimum rating	Class 3000 minimum rating	Class 6000 minimum rating	Class 6000 minimum rating	Class 6000 minimum rating	Class 6000 minimum rating
Valves	N/A	ASME 900 or 3000# WOG minimum rating	N/A	ASME 900 or 3000# WOG minimum rating	N/A	Class 5000 minimum rating

5.25.2 Except as permitted in Clauses 5.11.1, 5.25.1 and 5.25.3 of this Specification, ancillary piping connections shall be socket welded.

5.25.3 Valves for ancillary piping for belowground valves shall be lockable full port SW X FNPT ball valves with a minimum rating as shown in Table 5-2. Preferred valves shall be as shown in Table 5-3 and the use of any other ancillary valves shall be subject to the written acceptance of the Company. The valves shall be oriented with the run vertical/stem horizontal and shall have a 90-degree forged steel threaded elbow installed on the downstream end of the valve. A 12.7 mm (½ in.) NPT stainless steel threaded body vent fitting and carbon steel reducing bushing, if applicable, shall be installed downstream of the elbow.

Table 5-3: Preferred Brands for Ancillary Valves

Brand	Model #
Nutron	T3
WKM	310C
Energy Valves	Series 3000
Schuck	Type G
JAG	T3
Guide Valve Limited	VCI 201F

5.25.4 Threaded connections shall not be seal welded unless written approval is obtained from the Company.

5.25.5 Extended sealant lines attached to the valve at the time of shipment shall be filled with Sealweld Equilube 80, Sealweld Winterlube 7030, Valtex 80, Valtex 750, or an equivalent accepted in writing by the Company. Stem sealant lines shall be permanently identified as such so they are readily distinguishable from seat sealant lines.

5.25.6 Ancillary piping shall be adequately supported and protected from damage during transportation, installation and service.

5.25.7 Drain lines shall be permanently identified as to their specific function.

5.25.8 Any valve body cavity vent ports shall be sealed with a solid threaded plug.

6 MATERIALS

6.1 Material Specification

6.1.1 All materials for pressure-containing parts other than bolting shall be approved by the Company and documented in the technical agreement signed by the Company and the Manufacturer.

6.1.2 Lubricating grease used in all gear sets shall be suitable for effective operation at -45°C (-49°F) unless a different temperature is specified on the request for quote and/or purchase order.

6.1.3 Unless otherwise permitted by the Company, ball, gate and check valves shall have non-metallic resilient seat inserts suitable for natural gas service.

6.3 Service Compatibility

6.3.1 Non-metallic materials shall be suitable for low temperature applications, but may have a glass transition temperature lower than -45°C (-49°F) unless a different temperature is specified on the request for quote and/or purchase order.

6.6 Toughness Test Requirements

6.6.1 All carbon and low-alloy steels for pressure-containing parts in valves shall be impact tested using the Charpy V-notch technique at the temperature specified on the request for quote and/or purchase order. It shall be permissible to conduct the tests at a lower temperature than the one specified.

Note:

Steels such as the AISI 4100 series are not considered to be low alloy.

6.6.2 All testing shall be conducted in accordance with the requirements of ASTM A370.

6.8 Sour Service

6.8.1 This Specification has not been written for the purchasing of valves for sour service. It applies to sweet natural gas service only.

7 WELDING

7.2 Welding Procedure and Welder/Welding Operator Qualifications

7.2.1 Welding, including repair welding, of pressure-containing and pressure-controlling parts shall be performed in accordance with procedures qualified to ASME Section IX or other Company-approved Industry Standards.

7.2.2 Welding procedures for the following welds shall be submitted for review and written acceptance by the Company prior to manufacture, or shall be documented in the Technical Agreement:

a) Pressure-containing fabrication welds including valve to pup welds.

b) Weld overlays and weld build-ups.

c) Weld repairs to the welds defined in (a) and (b).

d) Weld repairs to pressure-containing cast components.

Note:

QW-200.4 of ASME Section IX requires that the deposited weld metal of each process or procedure be included in the tension, bend and Charpy specimens.

Where pressure-containing cast components are obtained from a sub-vendor, the valve Manufacturer shall be responsible for obtaining the required weld repair procedures for submission to the Company.

7.3 Impact Testing

7.3.1 The welding procedure shall include impact test results for tests conducted in the weld and heat affected zone at a temperature of -45°C (-49°F) or lower, unless a different temperature is specified on the request for quote and/or purchase order.

7.5 Repair

7.5.1 Repair of Defects in Pressure Containing Castings

7.5.1.1 All repairs by welding shall be carried out using welders and welding procedures qualified in accordance with the requirements of Clause 7.2 of API 6D.

7.5.1.2 Defects shall be removed by suitable mechanical, thermal cutting or thermal gouging methods with the resultant cavity being thoroughly cleaned and suitably prepared for inspection by magnetic particle or liquid penetrant methods. This inspection shall be used to verify the complete removal of the defect.

7.5.1.3 When defects are removed by mechanical methods and where the depth of the cavity is equal to or less than 10 percent of the nominal wall thickness at a specific location, the excavated area shall either be blended uniformly into the surrounding surface or filled by welding.

7.5.1.4 When defects are removed by thermal cutting or gouging methods or when the depth of the cavity is greater than 10 percent of the nominal wall thickness at a specific

location, the excavated area shall be filled by welding. After repair, the surface shall be blended uniformly into the surrounding surface.

7.5.1.6 All major weld repairs to castings that are pressure-containing parts shall be heat-treated.

8 QUALITY CONTROL

8.1 NDE Requirements

8.1.1 Extent of Inspection

8.1.1.1 Welds and pressure-containing parts shall be non-destructively inspected as specified in Clauses 8.1.2 to 8.1.4, inclusive, of this Specification.

8.1.2 Casting Inspection

8.1.2.1 All pressure-containing castings shall be fully inspected by magnetic particle in accordance with the requirements of Annex G, Clause G.7 of API 6D.

8.1.2.2 Critical sections of pressure-containing cast components, as defined by the Manufacturer and as accepted in writing by the Company, shall be inspected by film radiography in accordance with the requirements of Annex G, Clause G.2 of API 6D or by ultrasonic testing in accordance to the requirements of Annex G, Clause G.4 of API 6D. Weld repairs to critical sections shall be inspected with the same method that detected the defect.

8.1.2.3 The buttwelding ends of all cast valves shall be inspected by film radiography in accordance with the requirements of Annex G, Clause G.3 of API 6D.

8.1.3 Weld Inspection

8.1.3.1 The following welds shall be radiographically and/or ultrasonically inspected for their full volume in accordance with the requirements of Clause 8.1.4.1 of this Specification:

a) Pressure-containing fabrication welds 60.3 mm (NPS 2) or larger.

b) Weld repairs to the welds defined in (a).

c) Except as allowed by Clause 8.1.3.2 (d) of this Specification, major weld repairs to pressure-containing parts.

8.1.3.2 The following welds shall be inspected using magnetic particle or liquid penetrant techniques and visual inspection in accordance with the requirements of Clause 8.1.4.1 of this Specification:

a) Welds joining a pressure-containing part that is smaller than 60.3 mm (NPS 2) to another pressure-containing part.

b) Welds joining a non-pressure-containing part to a pressure-containing part (e.g., lifting lugs, reinforcing plates, anchor pins).

c) Weld overlays and weld build-ups.

d) Major weld repairs to pressure-containing parts that only exceed the limits defined in the Glossary of this Specification and that have not been inspected in accordance with the requirements of Clause 8.1.3.1 (c) of this Specification, provided that the weld cavity, root pass and completed weld are inspected.

8.1.4 Acceptance Standards

8.1.4.1 Non-destructive inspection conducted in accordance with the requirements of Clause 8.1.3 of this Specification shall meet the applicable requirements of Annex G in API 6D.

8.1.5 Radiographs

8.1.5.1 All radiographs shall be identified and shall be made available to the Company representative, on request.

9 PRESSURE TESTING

9.1 General

9.1.1 The seat tests and the last portion of the shell test shall be conducted in the presence of the Company representative, unless otherwise agreed in writing by the Company.

9.1.2 The written test procedures shall be submitted for review and written acceptance by the Company prior to use, or shall be documented in the Technical Agreement.

9.1.3 Operational/functional tests shall comply with Annex H.6 of API 6D.

9.3 Hydrostatic Shell Test

9.3.1 The test duration shall be in accordance with the requirements of Table 9-1.

Table 9-1: Minimum Duration of Hydrostatic Shell Tests

Nominal Valve Size	Minimum Test Duration (minutes)	
	Shell Test – Cast Body	Shell Test – Fabricated or Wrought Body
Up to 457 mm (NPS 18)	120	30
508 mm (NPS 20) to 914 mm (NPS 36) incl.	240	60
Larger than 914 mm (NPS 36)	240	120
Note: Test duration of fabricated valves, which include castings as pressure containing components, shall be as shown for cast body valves.		

9.3.2 The test pressure, test duration and temperature of the pressure-test liquid shall be continuously recorded.

9.4 Hydrostatic Seat Test

9.4.2 Test Pressure and Duration

9.4.2.1 The test duration shall be in accordance with the requirements of Table 9-2.

Table 9-2: Minimum Duration of Seat Tests

Nominal Valve Size	Minimum Test Duration (minutes)
Up to 457 mm (NPS 18)	5
508 mm (NPS 20) to 914 mm (NPS 36) incl.	10
Larger than 914 mm (NPS 36)	15

9.4.3 Acceptance Criteria

9.4.3.1 The maximum permissible leakage rate for both hydrostatic and low pressure gas seat tests shall be ISO 5208 Rate A (no visually detectable leakage), except for metal seated check valves. Metal seated axial flow check valves shall not exceed ISO 5208 Rate D and metal-seated dual plate check valves shall not exceed 50 percent of that allowed by API 598.

9.4.4 Seat Test Procedures for Block Valves

9.4.4.3 Additional Seat Testing

9.4.4.3.1 Valves designed as double block and bleed (DBB) or double isolation and bleed (DIB-1) shall be subjected to additional seat testing as specified in Clause 9.4.4.3 of API 6D.

9.4.4.3.2 For all valves other than check valves, the valve shall be fully opened at the end of each seat test to demonstrate the satisfactory mechanical operation of the valve. The pressure on the seat when the valve is opened shall not be less than the maximum cold working pressure given in the applicable table of ASME B16.34.

9.4.4.6 Alternative Seat Test

9.4.4.6.1 At the Manufacturer's option, the alternative test described in API 6D may be conducted.

9.4.4.7 Low-pressure Gas Seat Testing

9.4.4.7.1 Type II low-pressure gas seat testing as specified in API 6D, Annex H.3 shall be conducted. Test duration shall be as specified in API 6D.

9.7 Draining

9.7.1 After successful completion of all pressure tests one of the lubricants specified in Clause 5.25.5 of this Specification shall be injected via the seat lubrication fitting in sufficient quantity to expel any test fluid that may have entered the lubricant passageways and seat ring channels.

9.7.2 If it is not possible to remove all test liquid from the body cavity prior to shipment, it shall be filled with a sufficient quantity of propylene glycol to prevent freezing of any remaining test liquid. The internal surfaces are to be dried with compressed air treated with rust inhibitor to provide a protective film.

9.7.3 Any ancillary valves shall be completely drained of water.

11 MARKING

11.1 For API certified valves, in addition to the markings required by Table 7 of API 6D, the following markings shall be added. Markings required by API 6D shall be in U.S. customary units (i.e., imperial units):

a) "API 6D" shall be stamped on the nameplate.

b) The API monogram shall be stamped on the nameplate, when applicable.

c) The traceability number shall be stamped on the nameplate and the body.

11.2 For CSA certified valves, markings as required by Clause 14.1 of CSA Z245.15 and the traceability number shall be included on the nameplate. All marking on this nameplate shall be in metric units.

11.3 For dual-certified valves, two nameplates (i.e., API and CSA) shall be provided.

11.4 Two sets of the applicable nameplate(s) shall be provided. One set shall be installed on the valve and the second set shall be attached with a wire to an appropriate location on the valve.

12 PREPARATION FOR SHIPMENT

12.1 Unless otherwise specified on the request for quote and/or purchase order, valve stem extensions shall be removed for shipping.

12.2 Unless otherwise agreed by the Company, valves shall be given a factory standard primer protective coating for protection during shipping.

12.3 Threaded and machined surfaces subject to corrosion shall be well protected by grease or other suitable inhibitors that will remain in place and will not deteriorate under atmospheric conditions before or during shipment.

12.4 The Manufacturer shall be responsible for suitably packaging the valve and all accessories to ensure protection from mechanical damage, moisture and debris during shipping and handling. All packaging and temporary closures shall be securely fastened. Welded attachments are prohibited. Flanged faces may be primed but not painted. End caps shall be installed before shipping.

12.5 Loose parts shall not be shipped inside any valve.

13 DOCUMENTATION

13.1 The documentation required by Clauses 13.2 to 13.10 of this Specification shall be submitted to the Company.

13.2 Except for bolting, the Manufacturer shall furnish a report of the heat analysis for each pressure-containing part 60.3 mm (NPS 2) and larger. A certificate of compliance shall be furnished for bolting for pressure-containing parts smaller than 60.3 mm (NPS 2).

13.3 The Manufacturer shall furnish a report of the product or heat analysis, as well as the carbon equivalent for the field weld ends.

13.4 Except for bolting, the Manufacturer shall furnish a report of the tensile tests and Charpy tests for each pressure-containing part 60.3 mm (NPS 2) and larger. A certificate of compliance shall be furnished for bolting for pressure-containing parts. Reports of Charpy V-notch tests shall include the following:

a) the test specimen size

b) the test specimen orientation

c) the test temperature

d) the actual test results for each test specimen

13.5 A permanent record of the shell test pressure, test duration and temperature reading experienced during the test period shall be recorded on a test chart and a copy shall be provided to the Company. A certified test report for the hydrostatic seat tests, the air seat tests and the operational tests shall be made and a copy shall be provided to the Company. The test charts and certified test reports shall be identified with the following:

a) name of valve Manufacturer

b) valve Manufacturer's shop order number

c) Company's purchase order number

d) valve serial number and model or figure number

e) date of the test

f) signature and job title of the Manufacturer's representative who witnessed the test

g) brand, serial number and calibration certificate of recording gauge

13.6 A written record of all non-destructive inspection results required by Clause 8.1 of this Specification shall be prepared and certified by the Manufacturer for submission to the Company.

13.7 The Manufacturer shall include a copy of the Company-accepted drawing in the documentation package.

13.8 The reports and test certificates shall contain the following additional information:

a) Confirmation that the valves have been manufactured in accordance with the requirements of this Specification and the latest signed Technical Agreement.

b) Make, model and serial number of manual gear set, if supplied with the valve.

13.9 A photocopy or “rubbing” of both nameplates on the valve.

13.10 The Manufacturer shall supply to the Company, prior to shipping the valve, reports and test certificates correlated to the valve serial number, the traceability number and the material number. The reports and test certificates shall be in a format acceptable to the Company.

15 PREPRODUCTION AND QUALIFICATION REQUIREMENTS

15.1 The Company shall supply the Manufacturer with a request for quote and, where applicable, a purchase order describing the operating conditions for which the valves are intended.

15.2 The Manufacturer shall supply the Company, at the time of quotation, any exceptions or alternatives to this Specification. Items covered by technical agreements need not be addressed at the time of quotation, as the technical agreements apply to each order.

15.3 As part of the qualification procedure, the Manufacturer shall submit the following documents and shall have received written acceptance of such from the Company:

a) The type of documented quality program being used and a copy of the registration certificate (see Clause 1.3.1).

b) Inspection and test plan (see Clause 1.6).

c) Pressure-relieving devices (see Clause 5.18.6).

d) Installation instruction for mounting extended stems, including vertical and horizontal installation (see Clause 5.18.9).

e) Stem extension and ancillary piping details, including bill of materials, attachment of ancillary piping to valve, pressure class and pipe schedule as applicable to pressure containing parts (see Clauses 5.24 and 5.25).

f) Alternative ancillary valves (see Clauses 5.10.2 and 5.25.3).

g) Materials for pressure-containing parts (see Clause 6.1.1).

h) Welding procedures (see Clause 7.2.2).

i) Definition of critical sections on castings (see Clause 8.1.2.2).

j) Ultrasonic inspection procedures for critical sections on castings, where applicable (see Clause 8.1.2.2).

k) Pressure test procedure (see Clause 9.1.2).

The Manufacturer shall provide sufficient notification informing the Company in writing of any changes to the above documents and shall obtain the written acceptance for such changes.

15.4 Drawings that include the following details shall be submitted by the Manufacturer for written acceptance by the Company. The drawings shall be resubmitted only when changes are made to them.

a) Outline dimensions.

b) For valves containing a field weld end, the weld end dimensions.

c) For valves containing welds defined in Clause 7.2.2 of this Specification, the thickness of the joint at the weld bevel. (This information may be shown as a note or sketch within the drawing.)

d) Welding procedure to be used for welds defined in Clause 7.2.2 of this Specification.

e) Company SAP material number and Manufacturer model number.

f) Bill of Materials for pressure-containing parts and lifting lugs.

g) Minimum design temperature.

h) Applicable Company Specification, revision number and revision date.

i) Valve operator mounting details.

j) The size of the drain connections.

k) The size of the body vents.

l) Drawing number and revision number, along with revision description, if applicable.

16 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are listed in Table 16-1, Table 16-2 and Table 16-3. Use the latest document revision, unless otherwise approved by TransCanada.

Table 16-1: Regulatory References

Organization/Document No.	Title
National Energy Board (NEB)	SOR/99-294, *National Energy Board Onshore Pipeline Regulations (NEB OPR)*
NOM-007-SECRE	*Transporte de Gas Natural*
U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) Code of Federal Regulations (CFR)	Title 49 Part 192, *Transportation of Natural Gas and Other Gas by Pipeline: Minimum Safety Standards*
Various	Other applicable federal, provincial and territorial safety acts and regulations by the authority having jurisdiction

Table 16-2: External Industry References

Organization/Document No.	Title
American Society for Testing and Material (ASTM)	A106, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*
	E186, *Reference Radiographs for Steel Castings from 2" up to 4.5" in Thickness*
	E280, *Reference Radiographs for Steel Castings from 4.5" through 12"*
	E446, *Reference Radiographs for Steel Castings up to 2" in Thickness*
American Society of Mechanical Engineers (ASME)	B16.11, *Forged Fittings, Socket-Welding and Threaded*
Canadian Standards Association (CSA)	Z245.12, *Steel Flanges*
	Z245.15, *Steel Valves*
	Z662, *Oil and Gas Pipeline Systems*
International Organization of Standardization (ISO)	9001, *Quality Management Systems – Requirements*

Table 16-3: Internal References

Document No.	Title
For this Specification, there are no specific Internal references.	

17 DOCUMENT HISTORY

Rev.		
01	**Description**	**Effective Date**
	Revised document developed as part of Columbia Pipeline Integration.	2017-Aug-01
	Rationale Statement	**Responsible Engineer**
	This document was revised to address the following requirements: • Integration of Columbia Pipeline requirements.	Cindy Guan, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group, to integrate Columbia Pipeline requirements, and to make it more easily accessible to those who use it	Cindy Guan, P. Eng.

Rev.		
00	**Description**	**Effective Date**
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	**Responsible Engineer**
	This document was revised to address the following requirements: • Alignment with new document definitions, structure, and templates.	Cindy Guan, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group and to make it more easily accessible to those who use it.	Cindy Guan, P. Eng.

18 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
N/A	This Specification was updated and put into the new template. Changed name from TES-VALV-G to TES-MA-VALV-G following the new naming convention.

19 APPROVALS

APPROVALS		
Originator: Sandra Kleinsasser, P. Eng. Welding and Materials Engineering	Signature	Date: June 21, 2017
Reviewer: Jessica de Vries, P. Eng. Welding and Materials Engineering	Signature	Date: June 21, 2017
Reviewer: Jaclyn Brown, PE USGO Integrity Program Services	Signature	Date: 6/21/2017
Responsible Engineer: Cindy Guan, P. Eng. Welding and Materials Engineering	Signature June 21, 2017 Date	PROFESSIONAL ENGINEER ALBERTA XINGSHENG (CINDY) GUAN APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, Manager Engineering Technical Governance	Signature	Date: June 21, 2017

PURPOSE

This Specification describes requirements for the manufacturing design, fabrication, inspection, qualification, and testing of gas hydraulic and gas pneumatic valve operators, and the associated devices required for the control and operation of valves.

SCOPE / APPLICABILITY

This Specification applies to gas hydraulic valve operators, gas pneumatic valve operators, and all associated control and instrumentation piping, tubing, fittings, and valves. Refer to Appendix B for an illustration of the scope of this Specification. For typical field installed components, refer to *STDS-01-VA-03-001: Power Gas Installations VOP-1 to VOP-12*.

This Specification applies to operators installed on valves of all Nominal Pipe Sizes (NPS) and pressure ratings on natural gas transmission pipelines and natural gas facilities such as launcher/receiver stations, meter stations, and compressor stations.

This Specification does not apply to operators for valves installed in sour gas service.

This Specification does not apply to operators for valves installed as part of oil or liquid pipelines and/or oil or liquid facilities.

Within this Specification, TransCanada is referred to as the Company.

Within this Specification, the following terms and definitions apply for requirements:

- Shall—expresses a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard. Shall is not a recommendation but a requirement.
- Should—expresses a strong preference, recommendation or that which is advised, but not required.
- Must—denotes a requirement of the Company, for which no deviation or variance would be granted.
- May—expresses an option or that which is permissible within the limits of the standard.
- Consider—assumes that a competent person will evaluate options to fulfill the intent of the requirement and make a documented decision supported by evidence to ensure protection of people, equipment and the environment by achieving the appropriate level of functional integrity.

Wherein the Manufacturer’s literature, governmental or regulatory requirements conflict with this Specification, the more stringent requirement shall govern.

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1 GLOSSARY

Data Sheet

Additional technical information sheets supplied by the Company to the Manufacturer specifying any details that form part of the request for quotation, purchase order, or release order.

Gas/Hydraulic Valve Operator

A gas powered hydraulic operator with high pressure natural gas directed to gas hydraulic tanks with hydraulic fluid used as the working medium.

Gas/Pneumatic Valve Operator

A gas-powered operator with high pressure natural gas (Gas Direct) or pressure regulated natural gas (VOP-100 and VOP-101) directed to pistons with natural gas used as the working medium.

Manufacturer

A Manufacturer who submits a proposal in accordance with this Specification and thereby assumes overall responsibility for the design, manufacture, testing, operation, and performance of the gas powered hydraulic and gas pneumatic operators.

NDE

Non-Destructive Examination

NPS

Nominal Pipe Size

NPT

Nominal Pipe Thread

Operator

A Valve Operator or Actuator is the mechanism that provides the motive force and mechanical connection to open or close a valve. For the purpose of this specification, the term “operator” is used as opposed to “actuator”.

Pressure Containing

Any component NPS 2 or larger in size, and all weldments, that are subject to internal gas pressure, including those components and weldments used in the fabrication of a gas/hydraulic tank or power gas storage bottle.

Special Processes

Processes where the results of such processes cannot be fully verified by subsequent inspection and testing of the product and where processing deficiencies may become apparent only after product is in use.

VOP

Valve Operator Package

2 REQUIREMENTS

2.1 General Requirements

2.1.1 The Manufacturer is responsible for ensuring special processes, such as welding, are carried out by qualified personnel. Sufficient monitoring and control of process parameters shall be in place to ensure specified requirements are met.

3 PRE-PRODUCTION REQUIREMENTS

3.1 Welding and NDE Pressure Weld

3.1.1 Prior to commencement of production, the Manufacturer shall submit, or have previously submitted, for written acceptance by the Company, procedures for welding and non-destructive examination (NDE).

3.1.2 The Manufacturer shall inform the Company in writing of any changes to the above documents.

3.2 Welding Qualifications

3.2.1 The Company shall review welding procedures for the following welds and provide written acceptance of:

- pressure-containing fabrication welds
- weld overlays and weld build-ups to pressure containing parts
- weld repairs to the welds defined above
- welds used to attach non-pressure-containing parts to pressure-containing parts

3.2.2 For the welds listed in 3.2.1 that are not heat-treated, the Manufacturer shall ensure that the welding procedure shall include at least two micro-hardness traverses across the weld, heat-affected zones, and parent metal as shown schematically below. One traverse shall be between 1 mm and 2 mm from the outside surface of the test specimen, and one traverse shall be between 1 mm and 2 mm from the inside surface of the test specimen. Each traverse shall consist of the following:

- at least one reading taken within the weld
- at least one reading on each side of the weld in the heat-affected zone
- at least one reading on each side of the weld in the parent metal

All results shall be reported.

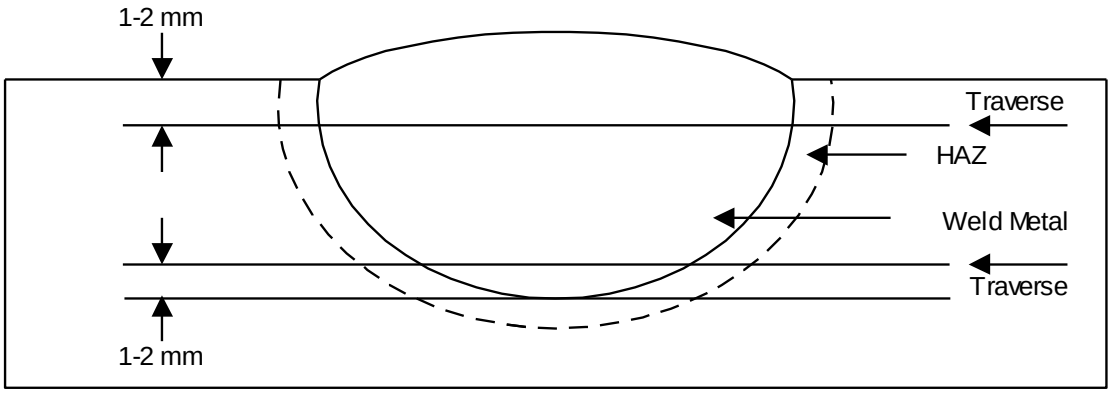


Figure 3-1: Traverses

3.2.3 The Manufacturer shall ensure that micro-hardness tests are conducted in accordance with the requirements of ASTM Standard E384.

3.2.4 The Manufacturer shall ensure that the hardness does not exceed 350 HV using a 500-gram load.

3.2.5 The Manufacturer shall ensure that evidence of written acceptance of the weld procedures are made available to the Company's representative at the time of inspection, if applicable. This evidence may be in the form of approved drawings, with the welding procedures referenced on the drawings.

3.2.6 The Manufacturer shall ensure that welds, defined in this section, are made using welders and welding procedures qualified in accordance with the requirements of *ASME Boiler and Pressure Vessel Code, Section IX*.

3.3 Standard Drawing

3.3.1 The Manufacturer shall submit, or have previously submitted, drawings for written acceptance, which shall include the following:

- outline dimensions of all operator sizes, mounting and assembly, and weights
- Bill of Materials for pressure-containing parts, including material designations
- NDE technique(s) employed, welding procedures used, design temperature, Specification number and revision date
- vent pipe design/assembly
- desiccant/filtration assembly
- control schematics and electrical wiring diagrams correlated to Valve Operator Package (VOP) numbers, as defined in section 9 or per the project-specific data sheet

3.4 Drawings for Approval

3.4.1 The Manufacturer shall supply one set of reproducible drawings, schematics, and bills of materials for Company approval.

3.4.2 The Company may waive approval drawings at their discretion, if pre-approved valve operator standard drawings, documents, schematics, and wiring diagrams are being used by the Manufacturer. Refer to section 3.3 for more information on standard drawings.

3.5 Confirmation of Order Information

3.5.1 The Manufacturer shall submit to the Company, at the time of quotation or acceptance of an order, the following information as a confirmation of order:

- purchase order specific information, including the purchase order number, material number, tag numbers, and project names
- manufacturer drawing numbers previously approved by the Company, to be used for operator fabrication and assembly
- torque and thrust capabilities at required differential pressures
- the make and model of the matching valve; and the torque or thrust requirements of that valve
- the valve and valve stem orientation
- the Valve Operator Package (VOP) number, if specified in the request for quotation
- the purchase order or data sheets
- the Company's data sheet number, if the VOP number above is not applicable
- any special requirements for operation and maintenance

4 OPERATOR PACKAGE DESIGN REQUIREMENTS

The requirements in this section apply to all operator packages, including both gas hydraulic and gas pneumatic packages.

4.1 Service Requirements

4.1.1 The Manufacturer shall ensure that the operator is suitable for use in high-pressure natural gas transmission service.

4.2 Design Codes and Standards

4.2.1 The Manufacturer shall ensure that valve operators, including the piping and pressure vessels, are designed, manufactured, inspected, and tested in accordance with the reference publications listed in this Specification.

4.3 Surface Preparation

4.3.1 The Manufacturer shall ensure that valve operators are blast-cleaned to a commercial blast finish (SSPC SP-6) or cleaner.

4.3.2 The Manufacturer shall ensure that valve operators are coated with an epoxy primer and topcoat. The topcoat colour shall be white.

4.3.3 The Manufacturer shall ensure that all normally exposed sliding stems or plungers are protected by flexible neoprene boots to prevent ice or paint build-up, corrosion, or inadvertent sand blasting.

4.4 Gate Valves (Gas Hydraulic or Gas Direct Operator)

4.4.1 The Manufacturer shall ensure that linear valve operators for gate valves incorporate mechanical position locks to allow positive positioning of the gate in any position.

4.5 Valve Operator Orientation

4.5.1 The valve position, orientation, and location (above or below ground) shall be specified on the purchase order or data sheet.

4.5.2 The Manufacturer shall ensure that the valve operators for ball and plug valves are built to allow installation on a vertical or horizontal stem orientation, as specified in the purchase order or Company data sheet.

4.5.3 The Manufacturer shall ensure that the valve operators for ball and plug valves ordered for a vertical stem orientation are built to allow installation in any 90° position around the centerline of the valve stem.

4.5.4 The Manufacturer shall ensure the valve operators are capable of functioning in the valve position specified on the purchase order or data sheet without malfunction or loss of hydraulic fluid.

4.6 Valve Operator Mounting

4.6.1 The Manufacturer shall supply all adapters and supporting hardware needed to match the operator to the top works of valves described in the purchase order or data sheet.

4.6.2 The Manufacturer shall ensure the operator yokes are keyed for keyed valves/stems. The Manufacturer shall determine and supply a shear key if one is required.

4.7 Operator End Stops

4.7.1 For rotating stems, the Manufacturer shall ensure the valve operator is equipped with externally adjustable end-of-stroke stops which shall provide a minimum of 2.5° stem rotation at each end of travel.

4.7.2 For linear stems, the Manufacturer shall ensure the valve operator is equipped with an externally adjustable end-of-stroke stop which shall provide a minimum of 1/2-inch gate adjustment at close end of travel.

4.7.3 The Manufacturer shall ensure that Operator End Stops can absorb the maximum torque or thrust output of the operator at the maximum power gas pressure.

4.7.4 The Manufacturer shall ensure that the Operator is fitted with a clearly distinguishable position indicator.

4.8 Valve Stem Loading

4.8.1 The Manufacturer shall ensure that the valve operator is designed to ensure that no side loading is imparted to the valve stem.

4.9 Power Gas Storage Tanks

4.9.1 When specified on the purchase order or data sheet, the Manufacturer shall ensure that a power gas storage bottle, with an isolating check-valve on the supply line, is incorporated on the power gas circuit to provide sufficient reserve for one valve closure at the minimum operating pressure.

4.9.2 The Manufacturer shall ensure that power gas storage tanks are designed, constructed, and tested in accordance with this Specification for a maximum design pressure of 9,930 kPa or greater, as specified in the project-specific data sheet.

4.9.3 The Manufacturer shall ensure that power gas storage tanks are provided with a drain plug, located at the bottom of the vessel.

4.9.4 The Manufacturer will determine if a CSA-approved factory sealed pressure relief valve is required on the power storage tank. The Manufacturer shall provide the relief valve, if required.

4.10 Seals

4.10.1 The Manufacturer shall ensure that dynamic, gas-wetted seals and O-rings are suitable for use with synthetic lubricants over the range -45°C to +45°C.

4.10.2 The Manufacturer shall ensure that seals withstand exposure to possible synthetic lubricant contamination in the power gas supply.

4.11 Integrally or Remote Mounted Equipment

4.11.1 The Manufacturer shall ensure that the valve operator is supplied with integrally mounted devices and components to provide a complete operating unit, to which the Company will make its electrical and gas connections (power gas and sensing lines).

4.11.2 When specified on the purchase order or data sheets, the Manufacturer shall ensure that the control devices, pumps, and tanks are mounted on a “Remote Mounted” stand.

4.12 Materials for Tubing and Instrument Fittings

4.12.1 The Manufacturer shall ensure that all tubing is bright annealed seamless stainless steel, in accordance with the requirements of *ASTM A269 Grade TP 304* or *TP 316*.

4.12.2 The Manufacturer shall ensure that all fitting material is *ASTM A182 Grade F316* stainless steel employing bite-type or compression-type flareless fittings. Fittings shall be SWAGELOK.

4.13 Power Gas Filters

4.13.1 The Manufacturer shall ensure that power gas and control gas are filtered by means of a dry-type filter that is provided as part of the operator assembly.

4.13.2 The Manufacturer shall ensure that filter elements are stainless steel, easily removed for cleaning, and shall be reusable.

4.13.3 The Manufacturer shall ensure that elements have filtration openings with dimensions that are no larger than 140 microns (0.0055 inch).

4.13.4 The Manufacturer shall ensure that the filter is equipped with a body drain.

4.14 Desiccant-Filter Package

4.14.1 The Manufacturer shall provide a standard desiccant-filter package, including a molecular sieve and a stainless steel filter (e.g., Fisher 252) in series, when requested in the data sheets or purchase order. The Manufacturer shall pre-submit the standard package to the Company for approval.

4.14.2 The Manufacturer shall ensure the desiccant-filter package is mounted on a sub-plate, which is mounted on the operator.

4.14.3 The Manufacturer shall ensure that all components in the desiccant-filter package are rated for a working pressure of 9,930 kPa or greater, as specified on the project-specific data sheet.

4.14.4 The Manufacturer shall ensure that the proper size of desiccant-filter package is supplied for the size of valve operator, based on a reduction of water content in the power gas supply from 4 lbs. H2O/MMSCF to 1 lbs. H2O/MMSCF.

4.14.5 The Manufacturer shall size the desiccant-filter package to provide sufficient flow to allow proper operation of the valve actuator under normal operating conditions.

4.14.6 The Manufacturer shall ensure that the stainless steel filter has filtration openings with dimensions that are no larger than 140 microns. The gas filter shall be easily removable and re-usable with a manual body drain.

4.15 Power Gas Venting

4.15.1 The Manufacturer shall ensure that at the end of valve travel, the power gas within the gas/hydraulic tanks is vented to atmosphere.

4.15.2 The Manufacturer shall supply NPS 2 power gas vent piping and install it at the top of the valve operator to allow the release of the vented gas.

4.15.3 The Manufacturer shall ensure that a provision is made to prevent weather elements or foreign objects that may cause blockage from entering the vent piping.

4.15.4 The Manufacturer shall provide an NPT drain port at the low point for the vent piping, allowing any liquids to be drained.

4.16 Test Ports

4.16.1 The Manufacturer shall ensure that pneumatic devices, subject to set point verification, calibration, and/or adjustment (e.g., line break devices, regulators), are furnished with a 1/4 inch NPT test port complete with a needle valve and a pipe plug.

4.16.2 The Manufacturer shall ensure the test can be performed with either hydraulic oil or gas, and that the hydraulic oil can be properly drained after testing if oil is used.

4.17 Enclosure

4.17.1 The Manufacturer shall ensure that the valve operator controls which enable manual operations, as defined in section 4.18, are housed and fitted with a locking door suitable for use with a standard padlock.

4.17.2 Enclosure is not required for VOP-100 and VOP-101 operators.

4.18 Operating Modes – Manual Control

4.18.1 The Manufacturer shall ensure that each valve operator is equipped with local manual control, so the valve may be opened or closed locally when power gas is available.

4.18.2 The Manufacturer shall ensure that remote automatic control signals will override the local manual control upon release of the local manual control lever.

4.18.3 The Manufacturer shall ensure that each valve operator has labels describing operating direction and identification for manual controls clearly displayed on the valve operator.

4.19 Operating Modes – Hand-Pump Control

4.19.1 The Manufacturer shall ensure that each valve operator is equipped with a hand-pump so the valve can be operated manually at the full differential pipeline pressure.

4.19.2 The Manufacturer shall ensure that the hand-pump is equipped with an open/close control lever. Setting the control lever to open or close shall enable hand-pump operation.

4.19.3 The Manufacturer shall ensure that the open/close control lever on the hand-pump provides positive indication locally that the hand-pump is in the manual mode (i.e., open or closed position). Alternately, if the lever is left in the open or closed position, it shall reset to the normal control position automatically when the local manual control is disengaged, or the remote automatic control is initiated.

4.19.4 The Manufacturer shall ensure that the hand-pump control system does not allow potentially dangerous sudden movement of the hand-pump lever when local manual control or remote automatic control is initiated.

4.19.5 A hand-pump is not required for VOP-100 and VOP-101 operators.

4.20 Lifting Ring

4.20.1 The Manufacturer shall ensure that each valve operator has lifting ring(s) attached at the top so that the entire operator, fully filled with hydraulic oil, can be lifted and installed.

4.21 Marking

4.21.1 The Manufacturer shall ensure that all marking applied to pressure containing parts are made using low stress stamps.

4.21.2 In addition to markings required by *ASME Section VIII Div. 1* and/or the Provincial Authority having Jurisdiction (e.g. ABSA), the Manufacturer shall ensure that the valve operator is marked with the following information:

- CSA electrical design classification
- design pressure
- minimum design temperature in degrees Celsius
- serial plate, which includes:
  - operator serial number
  - operator model number
  - maximum working pressure
  - purchase order number and item number
  - valve identification number / tag number
  - name of Manufacturer
  - date of manufacture (year and month)

5 GAS HYDRAULIC OPERATOR-SPECIFIC DESIGN REQUIREMENTS

The requirements in this section are specific to gas hydraulic operator packages. They are in addition to the requirements listed in section 4: Operator Package Design Requirements.

5.1 General Requirements

5.1.1 The gas/hydraulic valve operator shall operate with natural gas directed to the gas hydraulic tanks.

5.1.2 The Manufacturer shall ensure that the hydraulic fluid contained in the gas hydraulic tanks are the working medium of the operator.

5.1.3 The gas hydraulic valve operator shall operate with high-pressure natural gas or regulated gas to a pressure not exceeding the maximum working pressure of the operator.

5.2 Registration

5.2.1 The Manufacturer shall be responsible for complying with any pressure vessel registrations within the province which the valve operator is installed.

5.3 Gate Valves

5.3.1 The Manufacturer shall ensure that the hydraulic circuit includes thermal pressure relief protection to prevent damage to the operator.

5.3.2 Based on the gate valve function and service conditions, the Company will determine the need for an accumulator to be used for the prevention of temperature induced creep. If an accumulator is required, it shall be quoted by the Manufacturer at the time of order.

5.4 Gas Hydraulic Tanks

5.4.1 The Manufacturer shall ensure that the gas hydraulic tanks are designed, constructed, and tested in accordance with this Specification for a maximum design pressure of 9,930 kPa or greater, as specified in the project-specific data sheet.

5.4.2 The Manufacturer shall ensure that the tanks are supplied with the initial fill of hydraulic fluid.

5.4.3 The Manufacturer shall ensure that the gas entry port of the tank is fitted with a diffuser to prevent the power gas from foaming or churning the hydraulic fluid.

5.4.4 The Manufacturer shall ensure that the hydraulic fluid exit port on the tank is fitted with a riser so that sufficient sump volume exists in the tank to prevent contaminants or condensation from entering the operator cylinder.

5.4.5 The Manufacturer shall ensure that provisions are made to drain contaminants or condensation without removing the riser fitting.

5.4.6 The Manufacturer shall ensure that each tank has a drain plug on the bottom, which enables the hydraulic oil to be drained.

5.4.7 Prior to assembly, the Manufacturer shall ensure that the internal surfaces of the tanks are thoroughly shot blast cleaned to remove mill scale and rust.

5.5 Seals

5.5.1 Elastomer seals and control/power block components machining tolerances shall be compatible with Esso Univis HVI-13, Marinus, or other eco-friendly hydraulic oils.

5.6 Hydraulic Fluid

5.6.1 The Manufacturer shall ensure that the hydraulic fluid used is Esso Univis HVI-13, or a Company-approved equal.

6 GAS PNEUMATIC OPERATOR-SPECIFIC DESIGN REQUIREMENTS

The requirements in this section are specific to gas pneumatic operator packages. They are in addition to the requirements listed in section 4: Operator Package Design Requirements.

6.1 General Requirements

6.1.1 The valve operator shall operate with high-pressure natural gas or regulated gas to a pressure not exceeding the maximum working pressure of the operator.

6.2 Valve Operator Mounting

6.2.1 The Manufacturer shall provide wrench override adaptors for VOP-100 and VOP-101.

7 ENGINEERING REQUIREMENTS

7.1 Valve Data

7.1.1 Where insufficient data is available from the valve Manufacturer, the Manufacturer may utilize data available for comparable valves. Where such assumed data is used, the Manufacturer shall obtain the Company's prior written approval.

7.2 Normal Operating Conditions

7.2.1 The valve operator will operate under non-corrosive gas service. Valve operator materials shall be suitable for exposure to sweet natural gas that may contain by-products of processing and treating natural gas.

7.2.2 The Manufacturer shall ensure that the valve operator is designed to operate at ambient temperatures of -45°C to +45°C.

7.3 Power Gas Supply

7.3.1 The valve operator power gas supply will be natural gas, taken from the pipeline.

7.3.2 The Manufacturer shall ensure that the valve operator can operate at a power gas pressure range from a maximum working pressure of 9,930 kPa or greater, as specified on the data sheet, to a minimum of 2,410 kPa, unless otherwise specified in the purchase order or data sheet.

7.4 Valve Low Temperature Service

7.4.1 Buried valves will have a low service temperature of -5°C. Valves installed for above ground service will have a low service temperature of -45°C. The Company may specify lower temperatures than those specified above for buried and above ground service as required; in such cases, the specified minimum service temperature will be included in the purchase order or Company data sheet.

7.5 Speed Controls and Limiting Device

7.5.1 The Manufacturer shall ensure that independently adjustable speed controls are provided to regulate the operating speed of the valve over the stroking time.

7.5.2 The Manufacturer shall ensure that the maximum actuation time is as follows:

- For ball valves and plug valves: One second per inch of nominal valve size for valves NPS 16 and larger; 15 seconds for valves smaller than NPS 16.
- For gate valves: Five seconds per inch of nominal size.

7.6 Valve Torque and Thrust

7.6.1 The Manufacturer of the valve operator shall determine the minimum output torque or thrust of the valve operator, and applicable safety factors, over the range of operating pressures and temperatures specified in consultation with the valve manufacturer.

7.6.2 The Manufacturer shall ensure that the maximum operator torque (ball and plug valves) or thrust (gate and rising stem valves) required to operate the valve does not exceed the maximum safe allowable valve torque or thrust.

7.6.3 The Manufacturer shall ensure that the valve operator is capable of fully stroking the valve to an open or closed position over the range of operating pressures: from a maximum of 9,930 kPa to a minimum of 2,410 kPa, or as specified on the data sheet.

7.6.4 For calculating the operator torque or thrust requirements, the Manufacturer shall ensure that a maximum differential pressure across the valve is 9,930 kPa or as specified on the data sheet.

8 ELECTRICAL REQUIREMENTS

8.1 Classification of Equipment

8.1.1 The Manufacturer shall ensure that all electrical devices and enclosures are CSA approved for use in Class I, Division 1, Group D hazardous areas. All devices are to be NEMA recognized and IEC devices are not acceptable.

8.1.2 The Manufacturer shall ensure that electrical equipment bears the label of a recognized certification organization that indicates the equipment has been certified to CSA standards.

8.2 Solenoid Control Valves

8.2.1 The Manufacturer shall ensure that solenoid control valve coils are single-coil epoxy-potted with leads effectively sealed or clamped where the windings are connected.

8.2.2 The Manufacturer shall ensure that DC solenoids have a minimum operating range of -15% to +10% (dropout) of nominal voltage.

8.2.3 The Manufacturer shall ensure that solenoid voltage requirements are as specified on the data sheet.

8.2.4 The Manufacturer shall ensure that solenoid control valves can operate at an ambient temperature of -45°C.

8.2.5 The Manufacturer shall ensure that solenoids are 24 VDC.

8.3 Position Limit Switches

8.3.1 The Manufacturer shall ensure that valve operators are fitted with end-position limit switches to indicate both open and closed positions if required.

8.3.2 The Manufacturer shall ensure that limit switch assemblies permit end-of-valve-travel adjustment.

8.3.3 The Manufacturer shall ensure that limit switches be located inside a CSA approved enclosure.

8.3.4 The Manufacturer shall ensure that pressure and/or limit switch contact ratings are, at a minimum:

- 125 VDC 0.4 Amps (resistive)
- 24 VDC 1.00 Amps (resistive)
- 120 VAC 5 Amps (resistive)

8.4 Junction Box

The Manufacturer shall ensure that all electrical controls, limit switches, and solenoid valves are brought to terminal blocks in a common junction box, clearly marked for the Company's connections. This may be supplied as a separate junction box, or as part of the limit switch assembly.

8.4.1 The Manufacturer shall ensure that space is provided to allow for the installation of electrical suppression devices in the junction box.

8.4.2 The Manufacturer shall ensure that the junction box can accommodate a minimum size of 1 1/4 inch NPT conduit entry for customer connection, and is equipped with an internal grounding connection and terminal blocks capable of connecting 14 AWG conductors. All terminal blocks shall be screw type terminals.

8.4.3 The Manufacturer shall ensure that electrical components are corrosion-resistant and NEMA rated.

8.4.4 The Manufacturer shall ensure that all enclosures shall meet area classification requirements and shall be marked with appropriate certification. Mounting design and bracing shall be installed to allow ease of access to equipment and to minimize vibration. For outdoor applications, breathers and drains must be flush-mounted and installed to meet CEC requirements.

8.5 Pressure Switches

8.5.1 The Manufacturer shall ensure that pressure switches are installed on the valve operator. The requirements for these switches apply only to Valve Operator Packages SB-1930 to SB-1943.

9 EXAMINATION AND TESTING REQUIREMENTS

9.1 Radiographic Examination

9.1.1 Pressure containing butt weld seams in gas/hydraulic tanks and power gas storage tanks defined by ASME Section VIII and CSA B51 as pressure vessels shall be fully radiographed.

9.1.2 The Manufacturer shall ensure that radiographic techniques and acceptance standards are in accordance with *ASME Boiler and Pressure Vessel Code Section VIII, Division I,* paragraph UW-51.

9.1.3 Pressure containing butt weld seams in gas/hydraulic tanks and power gas storage tanks defined by *ASME Section VIII* and *CSA B51* as fittings shall be, as a minimum, subject to spot radiography in accordance with ASME *Boiler and Pressure Vessel Code* Section VIII, Division I.

9.2 Visual Examination

9.2.1 The Manufacturer shall ensure that all welds, as defined in section 3.2, are free of detrimental surface indications, including but not limited to, pinholes, cracks and undercuts.

9.2.2 The Manufacturer shall ensure that the welds are evaluated visually, or by using another suitable non-destructive examination method.

9.2.3 The Manufacturer shall ensure that any injurious indications detected are removed and/or repaired, as allowed by *ASME Section VIII, Division I*.

9.3 Pressure Testing

9.3.1 The Manufacturer shall ensure that the hydraulic system, including any CSA B51 or ASME Section VIII, Division I certified valve operator components that are part of the hydraulic system, are hydrostatically pressure tested at 1.5 times their design pressure for a minimum of 30 minutes.

9.3.2 The Manufacturer shall ensure that pressure charts are supplied to the Company identifying the date, test number, purchase order number, the test pressure, test duration, and any additional test details, as stated on the purchase order.

9.3.3 The Manufacturer shall ensure that the completely assembled valve operator package is dry-compressed air-tested at 1.1 times the design pressure and checked for leakage.

9.4 Function Testing

9.4.1 The Manufacturer shall ensure that the complete valve operator package is function-tested. The tests shall conform, as closely as possible, to actual field-operating conditions.

10 TECHNICAL DOCUMENTATION

10.1 Reports and Certificates

10.1.1 Prior to shipping the valve operator, the Manufacturer shall supply to the Company, or its representative, one (1) copy of the reports and test certificates.

10.1.2 The reports and test certificates shall contain the following information with a cover transmittal listing the documents in the order attached:

1. Material test results for pressure containing components
2. Hydrostatic test charts
3. Certification of the weld procedures used
4. Nondestructive examination records
5. ASME data sheet U1A, if applicable
6. Confirmation that the valve operator was manufactured in accordance with this specification and revision date
7. Company Purchase Order Number (P.O. No.) and Construction Project Number (C.O. No.), if applicable
8. One copy of the Manufacturer's approved drawing(s) that were shop referenced in the purchase order or confirmation of order
9. One photocopy of the serial name plates for the specific operator(s) related to the purchase order
10. Enclosure certification for area classification application (where applicable)

10.2 Instruction Manuals

10.2.1 Two (2) copies of the instruction manuals shall be shipped with the valve operator to the site.

10.2.2 One (1) copy of the instruction manuals shall be shipped to the Company's head office Vendor Document Control.

10.2.3 Each instruction manual shall include the following:

- equipment description including design data, ratings, and set points
- installation instructions and operation procedures
- maintenance and troubleshooting procedures
- reduced size assembly, control and schematic drawings and bills of materials

11 PREPARATION FOR SHIPMENT

11.1.1 The Manufacturer shall ship the valve operators in the fully open position, individually boxed or crated as necessary for protection against mechanical and environmental damage during shipment. Items that must be shipped loose shall be placed in a separate container that is tagged for identification.

11.1.2 The Manufacturer shall lightly grease exposed machined surfaces and ensure they are protected from damage.

12 VALVE OPERATOR PACKAGES

12.1 General

12.1.1 Functional Applications

Functional applications, per sections 12.2, 12.3 and 12.4, describe the facility reference and titles of the valve. A Valve Operator Package (VOP) number references each application and provides the functional design requirements, the Manufacturer's standard schematic, and wiring drawing numbers for procurement of a gas hydraulic valve operator.

12.1.2 Standard Valve Operator Packages

A Standard Valve Operator Package number identifies the instrumentation and control requirements for each valve functional application. The valve operator packages are identified as VOP-1 to VOP-12, SB-1930 to SB-1943, and VOP-100, VOP-101.

The Company shall note and enter this number in the project data sheet and in the purchase requisition/order when specifying the valve operator for procurement.

The Manufacturer does not require a copy of the project data sheet because the valve operator Vendor drawings are approved for each Standard Valve Operator Package number. Data sheets for non-standard valve operator packages, other than the ones listed previously, will be required on a project-specific basis.

12.1.3 Valve Operator Data Sheet Templates

A standard data sheet template for each valve operator package is used to identify the specific site requirements. The data sheet templates are identified as VOP-1 to VOP-12, SB-1930 to SB-1943, and VOP-100 and VOP-101.

VOP-1 to VOP-12 can be used on all TransCanada systems. SB-1930 to SB-1943 can only be used on TransCanada Mainline systems east of Alberta where existing facilities already have the controls systems in place pertaining to the SB packages.

The Company shall update the data sheets for site-specific design with reference and service information, such as project name, and tagging and valve information. The technical requirements are standardized with Vendor drawing approval.

12.2 Valve Operator Package Descriptions (VOP-1 to VOP-12)

12.2.1 The technical requirements for valve operator packages VOP-1 to VOP-12 are summarized in the following table. See Appendix A for approved schematic and wiring diagram numbers that represent each vendor-approved valve operator package.

Table 12-1: Valve Operator Packages VOP-1 to VOP-12

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS (E.g.)	FUNCTIONAL REQUIREMENTS
VOP-1	Pipeline Scraper Trap, Isolation Valve	• Manual operation • No I&C requirements • Power gas high pressure selector valve
VOP-2	Pipeline Mainline, Side, Crossover, Isolation Valve	• Manual operation • Low pressure closedown device (set point 3,450 kPa(g) falling) • Auto/maintenance selector valve • Low pressure select manifold • Power gas high pressure selector valve
VOP-3	Pipeline Mainline, Side, Crossover, Isolation Valve	• Manual operation • High pressure closedown device (set point 7,500 kPa(g) rising) • Auto/maintenance selector valve • High pressure select manifold • Power gas high pressure selector valve
VOP-4	Pipeline Mainline, Side, Crossover, Isolation Valve	• Manual operation • Low pressure closedown device (set point 3,450 kPa(g) falling) • Auto/maintenance selector valve • Limit switch assembly • Low pressure select manifold • Power gas high pressure selector valve

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS (E.g.)	FUNCTIONAL REQUIREMENTS
VOP-5	Pipeline Mainline, Side, Crossover, Isolation Valve	• Manual operation • High pressure closedown device (set point 7,500 kPa(g) rising) • Auto/maintenance selector valve • Limit switch assembly • High pressure select manifold • Power gas high pressure selector valve
VOP-6	Compressor Station Mainline Block Valve (Pre-1996 Design)	• One way remote control • Low pressure closedown device (set point 3,450 kPa(g) falling) • Differential pressure inhibit device (set point 350 kPa(g) falling) • Bi-directional differential pressure selector • Auto/maintenance selector valve • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (one solenoid): ▪ De-energize to open ▪ Energize to enable manual close
VOP-7	Compressor Station Mainline Block Valve (Post 1996 Design)	• Two way remote control • Low pressure closedown device (set point 3,450 kPa(g) falling) • Differential pressure inhibit device (set point 350 kPa(g) falling) • Bi-directional differential pressure selector • Auto/maintenance selector valve • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (one solenoid): ▪ De-energize to open ▪ Energize to close

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS (E.g.)	FUNCTIONAL REQUIREMENTS
VOP-8	Compressor Station Suction/Discharge Side Valve, Isolation Valve	• One way remote control • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (one solenoid): ▪ De-energize to close ▪ Energize to enable manual open
VOP-9	Compressor Station Blowdown Valve	• One way remote control • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (one solenoid): ▪ De-energize to open ▪ Energize to enable manual close
VOP-10	Meter Station/Pipeline Run Switching Valve, Yard Valve	• Two way remote control • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (two solenoids): ▪ Energize to open ▪ Energize to close
VOP-11	Meter Station Sour Gas Block Valve	• One way remote control • Limit switch assembly • Power gas high pressure selector valve • Solenoid control (one solenoid): ▪ Energize to close ▪ De-energize to enable manual open
VOP-12	Meter Station Sour Gas Block Valve	• Two way remote control • Limit switch assembly • Differential pressure inhibit device (set point 350 kPa(g) falling) • Bi-directional differential pressure selector • Power gas high pressure selector valve • Solenoid control (two solenoids): ▪ Energize to open ▪ Energize to close

12.3 Valve Operator Package Descriptions (SB-1930 to SB-1943)

The technical requirements for valve operator packages SB-1930 to SB-1943 are provided in the following section. The approved Vendor schematic and wiring drawing numbers represent each valve operator packages as shown in Appendix B.

12.3.1 Pressure Switches, General Guidelines

The Manufacturer shall ensure that the valve operator, unless otherwise specified on the data sheets, includes a DPDT (Double Pole Double Throw) pressure switch connected to the power gas supply. The pressure switch shall be adjustable over a pressure range 2,000 kPa to 4,000 kPa and set to open at 2,800 kPa decreasing, unless otherwise specified in the data sheets.

1. Station Mainline Valves:
    - MLV PSL Pilot gas low pressure Single Pole Double Throw (SPDT) set at 550 kPa decreasing
    - ML PSL Mainline low discharge pressure DPDT set at 3,450 kPa decreasing
2. Station Side Valves Unit Suction and Plant Isolation Valves:
    - PDSL Pressure differential low DPDT set at 690 kPa decreasing
    - PR Line pressurized SPDT set at 690 kPa increasing
3. Suction and Discharge Blow-offs:
    - PSH Pressure switch high DPDT set as specified on the data sheets and to meet site requirements.

12.3.2 Main Line (Station By-Pass) Valve

The Manufacturer shall ensure that the Main Line (Station By-pass) valve operator is controlled by differential pressure across the main line valve, a *Lock-Closed* solenoid valve, a *Close* solenoid valve and a downstream pressure controlled pilot valve.

1. The Main Line Valve shall open if:
    - The line pressure on the suction side of the valve is greater than 35 kPa above the line pressure on the discharge side.
    - The *Lock-Closed* solenoid is de-energized.

    The set point of the differential control device shall be adjustable from approximately 0 kPa to 100 kPa.
2. A Main Line valve that is closed will remain closed if:
    - The *Lock-Closed* solenoid is energized, or
    - The line pressure on the discharge side of the valve is greater than on the suction side by 100 kPa.

3. The Main Line valve will close only if both the *Close* and *Lock-Closed* solenoids are energized. The *Close* solenoid will be de-energized when the valve has reached the closed position.
4. A low downstream pressure of 3,450 kPa falling (or as specified in the data sheets) shall cause the valve to close, if not already closed, and to stay closed until manually reset. As a minimum the set point of the sensing device shall be adjustable from 2,000 kPa to 5,520 kPa.
5. A pressure switch (MLV PSL) shall be activated at 550 kPa decreasing on low pilot gas pressure, indicating that the valve closed pneumatically on low downstream pressure.

12.3.3 Side and Isolation Valve

The Manufacturer shall ensure that a *Fail-safe* solenoid and an *Open* solenoid control side and isolation valve operators.

- The *Fail-safe* solenoid shall, when it is de-energized, cause the valve to close.
- The *Open* solenoid, when energized, shall cause the valve to open, but only if the *Fail-safe* solenoid is also energized. The *Open* solenoid shall be de-energized when the valve has reached its fully open position.

12.3.4 Suction and Discharge Blow-off Valve

The Manufacturer shall ensure that Suction and Discharge Blow-off valve operators are controlled by a *Close* solenoid, a *Fail-safe* solenoid, and a pressure relief switch.

- The valve shall close when the *Close* solenoid and the *Fail-safe* solenoid are energized. The *Close* solenoid shall be de-energized when the valve has reached its fully closed position.
- The valve shall open when the *Fail-safe* solenoid is de-energized.
- The valve shall open by de-energizing the *Fail-safe* solenoid when the line pressure is greater than the set point of the pressure relief switch. The valve will close when the switch has passed through its deadband, re-energizing both solenoids.

12.3.5 Crossover and Series Valve

The Manufacturer shall ensure that Crossover and Series valve operators are controlled by a *Fail-safe* solenoid and an *Open* solenoid.

- The *Fail-safe* solenoid shall, when it is de-energized, cause the valve to close.
- The *Open* solenoid, when energized, shall cause the valve to open, but only if the *Fail-safe* solenoid is also energized. The *Open* solenoid shall be de-energized when the valve has reached its fully open position.

12.3.6 Unit Suction Valve

The Manufacturer shall ensure that Unit Suction valve operators are controlled by a *Fail-safe* solenoid and an *Open* solenoid.

- The *Fail-safe* solenoid shall, when it is de-energized, cause the valve to close.
- The *Open* solenoid, when energized, shall cause the valve to open, but only if the *Fail-safe* solenoid is also energized. The *Open* solenoid shall be de-energized when the valve has reached its fully open position.

12.3.7 Unit Discharge Valve

The Manufacturer shall ensure that Unit Discharge valve operators are controlled by a *Fail-safe* solenoid and an *Open* solenoid.

- The *Fail-safe* solenoid shall, when it is de-energized, cause the valve to close.
- The *Open* solenoid, when energized, shall cause the valve to open, but only if the *Fail-safe* solenoid is also energized. The *Open* solenoid shall be de-energized when the valve has reached its fully open position.

12.3.8 Reciprocating Compressor Valve

The Manufacturer shall ensure that Reciprocating Compressor Unit valve operators are controlled by a *Close* solenoid and an *Open* solenoid.

- The *Close* solenoid shall, when it is energized, cause the valve to close. The solenoid shall be de-energized when the valve has reached its fully closed position.
- The *Open* solenoid shall, when it is energized, cause the valve to open. The solenoid shall be de-energized when the valve has reached its fully open position.

12.3.9 Compressor Station Tie-Over Valve

The Manufacturer shall ensure that Compressor Station Tie-Over valve operators are controlled by a *Fail-safe* solenoid and an *Open* solenoid.

- The *Fail-safe* solenoid shall, when it is de-energized, cause the valve to close.
- The *Open* solenoid, when energized, shall cause the valve to open, but only if the *Fail-safe* solenoid is also energized. The *Open* solenoid shall be de-energized when the valve has reached its fully open position.

12.3.10 Main Line (Pipeline) Valve and Loop Terminus Tie-Over Valve

The Manufacturer shall ensure that Main Line (Pipeline) and Loop Terminus Tie-Over valve operators incorporate the following features:

- Low Pressure Shut-off: A low downstream pressure of 3,450 kPa falling (or as specified in the data sheets) shall cause the valve to close if not already closed, and to stay closed until manually reset.
- Maintenance Mode: The low pressure shut-off function shall be defeated in this mode. This isolation of the low pressure shut-off feature shall allow maintenance and calibration checks of the low pressure shut-off devices without causing the Operator to close the valve.

- A power gas storage tank shall be provided as part of the valve Operator assembly. The power gas storage tank shall be connected to the pipeline by a check valve that will ensure the storage tank pressure equals the maximum pipeline pressure.
- Limit switches and solenoid valves for remote valve operation and monitoring will not be required unless stated on the data sheets. If required, remote operation and monitoring shall be controlled by a *Close* solenoid and an *Open* solenoid.
- The *Close* solenoid shall, when it is energized, cause the valve to close. The solenoid shall be de-energized when the valve has reached its fully closed position.
- The *Open* solenoid shall, when it is energized, cause the valve to open. The solenoid shall be de-energized when the valve has reached its fully open position.

12.3.11 Launcher/Receiver Valve

The Manufacturer shall ensure that launcher and receiver valve operators are supplied with manual controls.

12.3.12 Valve Operator Package Descriptions

The technical requirements for valve operator packages B-1930 to SB-1943 are summarized in the following table. These valve operator packages reflect the Company's Alberta facilities. See Appendix A for approved schematic and wiring diagram numbers that represent each vendor-approved valve operator package.

Table 12-2: Valve Operator Package Table SB-1930 to SB-1943

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS	FUNCTIONAL REQUIREMENTS
SB-1930	MAINLINE Station By-pass Valve	• Two solenoids – de-energize to open, energize to close • Limit switch • PGL, MLV PSL, and ML PSL pressure switches • Regulator and relief • J1 differential pilot or equivalent, end of stroke • Low pressure closedown device with manual reset • SJ31-B junction box or equivalent

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS	FUNCTIONAL REQUIREMENTS
SB-1931	PLANT Suction & Discharge Side Valve or Isolation Valve	• Two solenoids – energize to open, de-energize to close • Limit switch • SJ31-B junction box or equivalent • PGL pressure switch • PDSL differential pressure switch • PR line pressurized
SB-1932	PLANT Suction & Discharge Blow-Off Valve or Isolation Blow-Off Valve	• Two solenoids – de-energize to open, energize to close • Limit switch • SJ31-B junction box or equivalent • PGL pressure switch • PSH pressure switch
SB-1933	PLANT Suction & Discharge Crossover Valve, (Series Valve)	• Two solenoids – energize to open, de-energize to close • Limit switch • SJ31-B junction box or equivalent • PGL pressure switch • PDSL differential pressure switch • DPS-2F differential pressure selector or equivalent
SB-1934	UNIT Suction Valve	• Two solenoids – energize to open, de-energize to close • Limit switch • L.P. pressure switch • PDSL differential pressure switch • SJ31-B junction box or equivalent
SB-1935	UNIT Discharge Valve	• Two solenoids – energize to open, de-energize to close • Limit switch • PGL power gas pressure switch • SJ31-B junction box or equivalent
SB-1936	TAP VALVE, Recip. Compressor Unit Valve	• Two solenoids – energize both ways • Limit switch • PGL pressure switch • SJ31-B junction box or equivalent

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS	FUNCTIONAL REQUIREMENTS
SB-1937	LOOP TERMINUS Tie-Over Valve (Linear)	• Two solenoids – energize both ways • Limit switches • PGL pressure switch • Regulator and relief • End of stroke • PSL pressure switch • SJ31 junction box or equivalent • Low pressure closedown device shuttle valve • Storage tank with HP relief and check valve (extra) • Auto/maintenance selector valve
SB-1938	MAINLINE Pipeline Valve	• Pressurematic • R324 reversing relay or equivalent • End of stroke • Regular and relief • Storage tank with HP relief and check valve (extra) • Auto/Maintenance Selector Valve
SB-1939	LAUNCHER & RECEIVER Valve	• Two-way manual
SB-1940	STATION Upstream & Downstream Tie-Over Valve (Linear)	• Two solenoids – energize to open, de-energize to close • Limit switches • SJ31-B junction box or equivalent • PGL pressure switch
SB-1941	MAINLINE Pipeline Valve - Remote Control	• Two solenoids – energize both ways • Limit switch • PGL pressure switch • Regulator and relief • End of stroke • PSL pressure switch • SJ31 junction box or equivalent • Low pressure closedown device shuttle valve • Storage tank with HP relief and check valve (extra) • Auto/maintenance selector valve
SB-1942	LAUNCHER & RECEIVER By-pass Valve	• Two way manual • 3/4” locking block

VALVE OPERATOR PACKAGE NUMBER	FUNCTIONAL APPLICATIONS	FUNCTIONAL REQUIREMENTS
SB-1943	PLANT Suction & Discharge Side Valve or Isolation Valve (Linear)	• Two solenoids – energize to open, de-energize to close • Limit switches • SJ31-B junction box or equivalent • PGL pressure switch • PDSL differential pressure switch • PR line pressurized pressure switch

12.4 Valve Operator Package Descriptions (VOP-100 to VOP-101)

12.4.1 Valve Operator Package Descriptions

The technical requirements for valve operator packages VOP-100 and VOP-101 are summarized in the following table. Gas/Pneumatic operators are used for VOP 100 and 101. These valve operator packages are typically used for skid-mounted meter stations. See Appendix A for approved schematic and wiring diagram numbers that represent each vendor-approved valve operator package.

Table 12-3: Valve Operator Packages VOP-100 and VOP-101

VALVE OPERATOR PACKAGE #	FUNCTIONAL APPLICATIONS	FUNCTIONAL REQUIREMENTS

VOP-100	Meter Station
	Sour Gas Block Valve
		• One way remote control
		• Limit switch assembly
		• Solenoid control (One Solenoid):
		  ▪ Energize to close
		  ▪ De-energize to enable manual open
		• Disconnect and wrench override

VOP-101	Meter Station
	Auto/Sour Gas Block Valve
		• Two way remote control
		• Limit switch assembly
		• Differential pressure inhibit device (set point 350 kPa(g) falling),
		• Bi-directional differential pressure selector
		• Solenoid control (two solenoids):
		  ▪ Energize to open
		  ▪ Energize to close
		• Desiccant filter package
		• Pressure regulating system
		• Disconnect and wrench override

13 VARIANCES

Any deviation shall follow the TransCanada Management of Change (MOC) Variance Procedure. External Manufacturers shall contact the TransCanada Mechanical Design Engineer for variance approval.

14 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are detailed below in Table 14-1. Use the latest document revision, unless otherwise approved by TransCanada.

Table 14-1: External and Internal References

Document No.	Title
NEB OPR SOR/99-294	National Energy Board Onshore Pipeline Regulations (NEB OPR)
Industry Codes and Standards	
American Society of Mechanical Engineers (ASME)	Boiler and Pressure Vessel Code, Section VIII, Div. 1 Pressure Vessels
	ASME Boiler and Pressure Vessel Code, Section IX
	B31.3 Process Piping
ASTM Standard E384	Standard Test Method for Knoop and Vickers Hardness of Materials
ASTM A269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A182	Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
Canadian Standards Association (CSA)	B51 Code for the Construction and Inspection of Boilers and Pressure Vessels
	C22.1 Canadian Electrical Code Part 1, Safety Standard for Installations
	Z662 Oil and Gas Pipeline Systems
National Electrical Manufacturers' Association (NEMA)	ICS 1 – General Standards for Industrial Control and Systems
	ICS 1.1 – Safety Guidelines for the Application, Installation and Maintenance of Solid State Control
	ICS 4 – Terminal Blocks
	ICS 6 – Industrial Control and Systems Enclosures

Document No.	Title
Internal References – Documents Referenced by this Standard / Specification	
STDS-01-VA-03-001	Power Gas Installations VOP-1 to VOP-12
EDMS No. 1002558850	Valve Operator Datasheet Template VOP 100, 101
EDMS No. 1002558685	Valve Operator Datasheet Template SB1930-SB1943
EDMS No. 1002558787	Valve Operator Datasheet Template VOP 1-12

15 DOCUMENT HISTORY

Rev.		
02	**Description**	
	New Document.	2017-Feb-02
	Rationale Statement	
	This document merges the requirements of, and supersedes, the following Specifications: • TES-VOPR-GH Gas Hydraulic Valve Operator Specification (CDN) • TEP-VOPR-GH Gas Hydraulic Valve Operator Packages and Functional Applications • TCPL MS 12-001, Gas Powered Hydraulic Valve Operators • OVA Specification VO-1, Valve Operators – Gas / Hydraulic • ANG Specification ES 1202P, General Specification for Gas Powered Hydraulic Valve Operators It also complies with the new Company Specifications template.	Jason Lu, P.Eng.
	Impact Assessment Summary	
	N/A	Jason Lu, P.Eng.

16 APPROVALS

APPROVALS		
Originator: David Scalzo, EIT Design Services	Signature	Date: Jan. 25, 2017
Reviewer: Dmitry Ryapolov P. Eng. CGO Technical Support	Signature #84006	Date: Feb 02, 2017
Reviewer: Pam Balderston, P. Eng. Pipeline Engineering	Signature	Date: Feb 1, 2017
Reviewer: Jim W. White, P. Eng. Coastal GasLink Project	Signature	Date: Feb 1, 2017
Reviewer: Steve Foo, P. Eng. Measurement Engineering	Signature	Date: Jan. 27, 2017
Reviewer: Gerard Lalonde, P. Eng. Design Services	Signature	Date: Jan 25/2017
Responsible Engineer: Jason Lu, P. Eng. Design Services	Signature Date: Feb. 02 2017 PROFESSIONAL ENGINEER ALBERTA JASON S. LU APEGA Permit to Practice P7100	
Management Endorsement: Muhammad Riaz, Manager Design Services	Signature	Date: Feb. 02, 2017

APPENDIX A VALVE OPERATOR PACKAGE VENDOR DRAWINGS

Table 16-1: Valve Operator Package Vendor Drawings

VALVE OPERATOR PACKAGE #	EMERSON STANDARD DWG NO.		VALVITALIA STANDARD DWG NO.		BIFFI STANDARD DWG NO. (Note 1)	
	Schematic	Wiring Diagram	Schematic	Wiring Diagram	Schematic	Wiring Diagram
VOP-1	E-65000050	N/A	SF-GO-355	N/A	GIG-VOP-1, GPO-VOP-1	
VOP-2	E-65000346	N/A	SF-GO-353	N/A	GIG-VOP-2, GPO-VOP-2	
VOP-3	E-65000347	N/A	SF-GO-356	N/A	GIG-VOP-3, GPO-VOP-3	
VOP-4	E-65000348	E-65500050	SF-GO-357	SE-14-004	GIG-VOP-4, GPO-VOP-4	SEAAF049
VOP-5	E-65000349	E-65500050	SF-GO-358	SE-14-004	GIG-VOP-5, GPO-VOP-5	SEAAF049
VOP-6	E-65000350	E-65500051	SF-GO-359	SE-14-030	GIG-VOP-6, GPO-VOP-6	SEAAF049, SEADA172
VOP-7	E-65000351	E-65500052	SF-GO-378	SE-14-031	GIG-VOP-7, GPO-VOP-7	SEAAF049, VOP-7
VOP-8	E-65000340	E-65500052	SF-GO-379	SE-14-031	GIG-VOP-8, GPO-VOP-8	SEAAF049, VOP-8
VOP-9	E-65000353	E-65500051	SF-GO-380	SE-14-030	GIG-VOP-9, GPO-VOP-9	SEAAF049, VOP-6/VOP-9
VOP-10	E-65000354	E-65500053	SF-GO-381	SE-24-042	GIG-VOP-10, GPO-VOP-10	SEAAF049, VOP-10/VOP-12
VOP-11	E-65000355	E-65500053	SF-GO-360	SE-14-032	GIG-VOP-11, GPO-VOP-11	SEAAF049, VOP-11
VOP-12	E-65000356	E-65500053	SF-GO-354	SE-24-042	GIG-VOP-12, GPO-VOP-12	SEAAF049, VOP-10/VOP-12
SB-1930	E-65000070	E-65500070	N/A	N/A	GIG-SB-1930, GPO-SB-1930	SB-1930
SB-1931	E-65000071	E-65500071	N/A	N/A	GIG-SB-1931, GPO-SB-1931	SB-1931

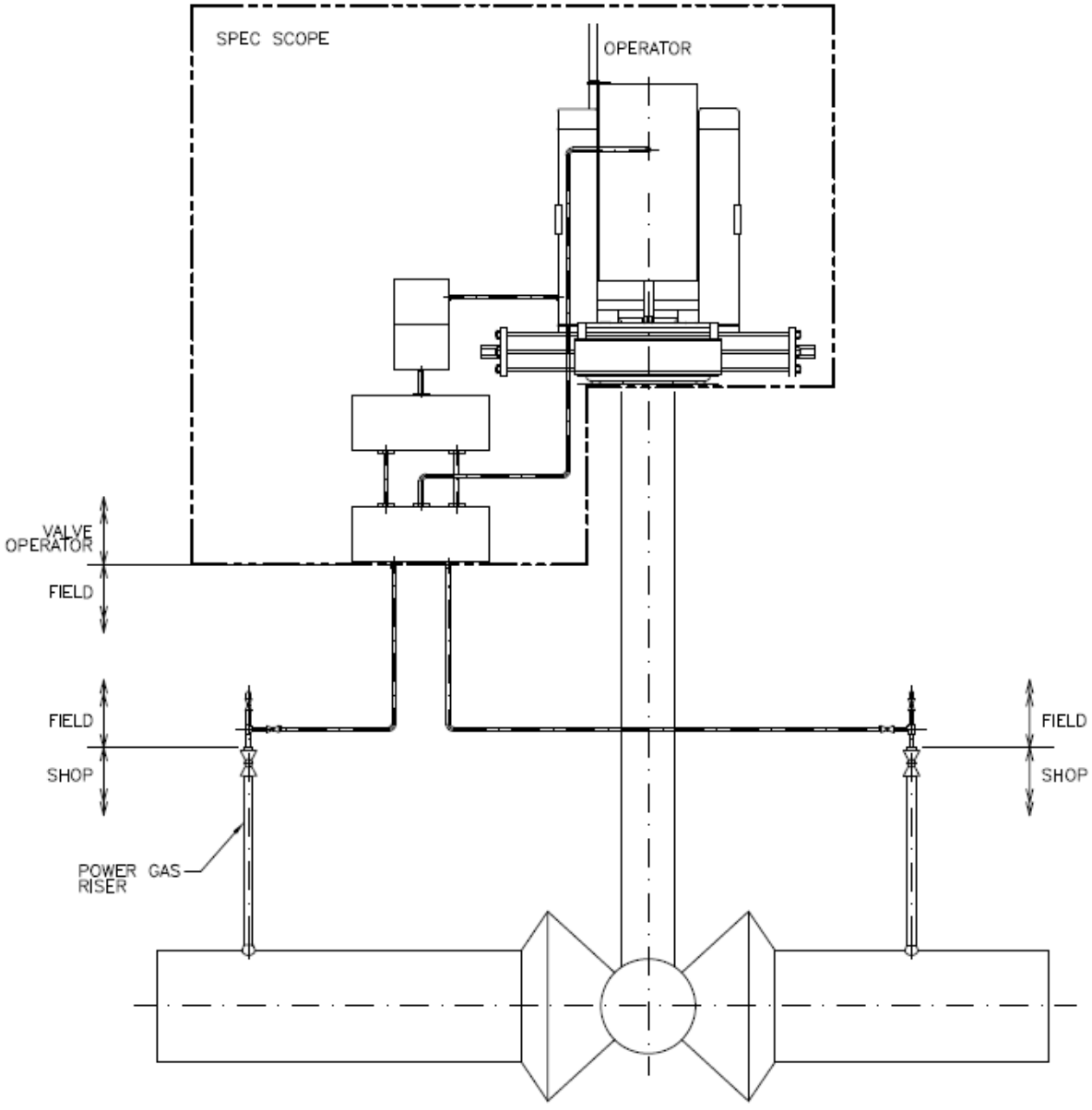
VALVE OPERATOR PACKAGE #	EMERSON STANDARD DWG NO.		VALVITALIA STANDARD DWG NO.		BIFFI STANDARD DWG NO. (Note 1)	
	Schematic	Wiring Diagram	Schematic	Wiring Diagram	Schematic	Wiring Diagram
SB-1932	E-65000072	E-65500072	N/A	N/A	GIG-SB-1932, GPO-SB-1932	SB-1932
SB-1933	E-65000073	E-65500073	N/A	N/A	GIG-SB-1933, GPO-SB-1933	SB-1933
SB-1934	E-65000074	E-65500074	N/A	N/A	GIG-SB-1934, GPO-SB-1934	SB-1934
SB-1935	E-65000075	E-65500075	N/A	N/A	GIG-SB-1935, GPO-SB-1935	SB-1935
SB-1936	E-65000076	E-65500076	N/A	N/A	GIG-SB-1936, GPO-SB-1936	SB-1936
SB-1937	E-65000077	E-65500077	N/A	N/A	GIG-SB-1937, GPO-SB-1937	SB-1937
SB-1938	E-65000078	E-65500078	N/A	N/A	GIG-SB-1938, GPO-SB-1938	N/A
SB-1939	E-65000079	E-65500079	N/A	N/A	GIG-SB-1939, GPO-SB-1939	N/A
SB-1940	E-65000080	E-65500080	N/A	N/A	GIG-SB-1940, GPO-SB-1940	SB-1940
SB-1941	E-65000081	E-65500081	N/A	N/A	GIG-SB-1941, GPO-SB-1941	SB-1941
SB-1942	E-65000082	E-65500082	N/A	N/A	GIG-SB-1942, GPO-SB-1942	N/A
SB-1943	E-65000083	E-65500083	N/A	N/A	GIG-SB-1943, GPO-SB-1943	SB-1943
VOP-100	SB-0326-71	S-0181-X01	N/A	N/A	N/A	N/A
VOP-101	SB-1114-7M	S-0225-X00	N/A	N/A	N/A	N/A

Note:

1. Link to BIFFI standard drawing and wiring diagram in EDMS will be added.

APPENDIX B SPECIFICATION SCOPE DRAWINGS

Figure B-16-1: Specification Scope



PURPOSE

This Specification outlines the requirements for the materials, qualification, manufacture, testing and inspection of double submerged arc welded steel line pipe.

SCOPE/APPLICABILITY

This Specification applies to double submerged arc welded pipe purchased for use in the Company's non-sour natural gas and liquid hydrocarbon pipeline systems in Canada, the United States (U.S.) and Mexico.

This Specification applies to pipe having a specified outside diameter (OD) of 406.4 mm OD (NPS 16) or larger, and pipe grade L690M (X100M) or lower.

This Specification does not apply to pipe for strain-based design, offshore and sour service.

This Specification is to be used in conjunction with the American Petroleum Institute (API) 5L *Specification for Line Pipe*, latest revision. This Specification covers requirements in addition to those of API 5L and any amendment, supplement or errata issued by API. All pipe shall meet, as a minimum, the requirements of API 5L.

The headings and numbering in this Specification correspond to those in API 5L. Where no incremental requirements are given in this Specification, API 5L shall apply as written. If conflict exists between this Specification and the requirements in API 5L, the more stringent of the requirements shall apply.

The Responsible Engineer shall be contacted for clarification if needed.

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GLOSSARY

ASME

American Society of Mechanical Engineers

ASTM

American Society for Testing and Material

CFR

Code of Federal Regulations

Company or Purchaser

TransCanada PipeLines Limited, its corporate affiliate or its agent.

CSA

Canadian Standards Association

DOT

United States Department of Transportation

Double-Jointer

Two pieces of pipe welded together to make a length 50 ft. (15.0 m) or longer.

ISO

International Organization for Standardization

Manufacturer or Vendor

Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.

MSS

Manufacturer Standardization Society

NEB

National Energy Board

NOM

Norma Oficial Mexicana

Purchase order

The purchasing document used to purchase the specified item(s).

Recrushed flux

Flux that fused during the original welding operation and has been ground and cleaned for re-use on subsequent welding.

Regulatory Authority

The national and/or local regulator having jurisdiction over the facility.

Rolling practice

The rolling parameters, which are within the essential parameters stated, are applied to a steel of specific alloy design to produce a steel having a desired set of physical properties.

Single-Jointer

Two pieces of pipe welded together to make a length shorter than 50 ft. (15.0 m).

Steelmaking practice

The specified chemical composition (including specified tolerances), refining and casting process used in making a heat of solid steel.

T-Joints

The junctions between the skelp end welds and helical seam welds.

Technical Agreement

The document signed by the Company and the Manufacturer that states an agreement on a technical matter.

Triple-Jointer

Three pieces of pipe welded together to make a length 50 ft. (15.0 m) or longer.

Virgin Flux

Flux that has not been used before or flux that has been used but did not fuse during the welding operation.

Welding Procedure

The Welding Procedure Specification, Procedure Qualification Record and all associated non-destructive and destructive test data.

WIC

Welding Institute of Canada

1 SCOPE

1.1 Purpose and Coverage

1.1.1 The requirements of the Annex documents referenced in this Specification, and the applicable Annex documents referenced in API 5L including Addendum documents thereto, shall be met as applicable. When specified, the pipe shall be dual-certified to meet CSA Z245.1, latest revision.

Pipe shall be supplied to meet the additional requirements outlined on the purchase order documentation or requests for proposal, whichever is applicable.

6 PIPE GRADE, STEEL GRADE AND DELIVERY CONDITION

6.2 Delivery Condition

6.2.3 All pipe shall, as a minimum, meet the product specification level PSL 2 requirements in regard to API 5L and Category II in regard to CSA Z245.1, if specified.

6.3 Right of Rejection

6.3.1 Where less than 50% of the pipe length formed from any heat, rolling practice, coil or lot complies with all other requirements of this Specification, the Company reserves the right to reject all pipe from the affected heat, rolling practice, coil or lot. The Manufacturer is responsible for obtaining the Company's written authorization prior to the acceptance of any pipe from such heats, rolling practice, coils or lots.

Note:

Right of rejection shall apply to issues associated with the manufacturing process.

6.4 Welder Qualifications

6.4.1 Pipe supplied for welder qualifications shall be of the highest carbon equivalent of the order.

8 MANUFACTURING

8.1 Process of Manufacture

8.1.1 Pipe furnished to this Specification shall be double submerged arc welded as defined in Clause 4.52, Clause 4.53, or Clause 4.54 of API 5L, as applicable.

8.3 Starting Material

8.3.2.1 The steel used for the manufacture of pipe shall be micro-alloyed, fine grain, fully killed, continuously cast steel with inclusion shape control. The steelmaking practice shall be identified with a steelmaking practice number.

8.3.2.2 The rolling practice shall be identified with a rolling practice number.

8.3.2.3 All skelp or all pipe shall be inspected for laminar-type imperfections by an ultrasonic procedure submitted to and accepted by the Company in writing prior to the commencement of production.

8.3.2.3.1 Any lamination in the body of the pipe or skelp shall be considered a defect if its non-destructively determined dimensions exceed both of the following:

a) ≥ 20 mm (0.79 in.) in the circumferential direction, and

b) an area of 7000 mm^2 (10.85 in^2.)

8.3.2.4 For all casting methods, the Manufacturer shall have a written method of monitoring the severity of centerline segregation present in either the slab or skelp to minimize the extent of segregation. This method shall be made available to the Company on request. The centerline segregation acceptance level shall be presented as part of the bid documentation.

8.3.10 Susceptibility of Pipe to Stress Relieving

Unless otherwise specified, tests outlined in Annex R of this Specification shall be conducted on pipe with a specified wall thickness greater than 31.8 mm (1.25 in.) to determine its susceptibility to stress relieving.

8.6 Weld Seams in SAW Pipe

8.6.1 Welding Procedure Qualification

8.6.1.1 a) Welding procedures for the longitudinal, helical, skelp end and circumferential welds, whichever are applicable, shall be qualified in accordance with the requirements of the latest edition of ASME *Boiler and Pressure Vessel Code* (BPVC), Section IX for each welding process, and for each flux trade name/designation and electrode designation combination employed.

b) When 100% virgin flux is used in production, the qualification tests shall be completed with virgin flux. When any amount of recrushed flux is used, the qualification tests shall include the recrushed flux. The percentage of recrushed flux used during production shall not exceed that used for the qualification tests.

8.6.1.2 A separate Procedure Qualification Record (PQR) shall be prepared for each grade of material. A change in grade shall be considered a change in an essential variable. The Welding Procedure Specification (WPS) and the PQR shall show "API 5L, Grade XXXXX"; where "XXXXX" is the grade defined in API 5L.

8.6.1.3 If the welding procedures to be used have not previously been accepted by the Company in writing, they shall be submitted for review and written acceptance by the Company. Pipe will not be considered for acceptance by the Company until the welding procedures have been accepted. Prior to the start of production, the Manufacturer shall provide the Company with the procedure numbers to be used for previously accepted procedures.

8.6.1.4 Procedure qualification testing shall include Charpy impact tests of the weld and heat-affected zone. Energy absorption and shear area requirements shall be in

accordance with the requirements of Clause 9.8.3 and Table 9-3 of this Specification. Test temperature shall be as specified in the purchase order. Tests conducted at lower temperatures shall be considered acceptable if the specified absorbed energy values are met at the lower test temperature.

8.6.1.5 Procedure qualification tests shall include at least two macrohardness traverses across the weld, heat-affected zones and parent metal. One traverse shall be between 1 and 2 mm (0.04 and 0.08 in.) from the outside surface of the test specimen and one traverse shall be between 1 and 2 mm (0.04 and 0.08 in.) from the inside surface of the test specimen. Each traverse shall consist of the following: at least two readings taken within the weld, at least two readings on each side of the weld in the heat-affected zone, and at least two readings on each side of the weld in the parent metal. Along each traverse, the hardness indentations shall be made on the microstructures expected to have the highest hardness within each zone. All results, including reading locations and distances from the specimen surface, shall be reported.

8.6.1.6 Macrohardness tests shall be conducted in accordance with the requirements of ASTM Standard E92.

8.6.1.7 The maximum macrohardness shall be 280 HV using a load of 10 kg.

8.6.2 Repair Welding

8.6.2.1 Limitations on Repair Welding

Defects in the longitudinal, helical or circumferential seams, or in skelp end welds of double submerged arc welded pipe, shall be subjected to weld repair in accordance with requirements of this Specification, and Annex C of API 5L. In addition to requirements outlined in C.4 of Annex C of API 5L, the following requirements shall apply:

a) All repairs by welding using other than the submerged arc process shall be preheated to a temperature of at least 120°C (250°F). Care should be taken to prevent overheating and no part of the area shall be heated above 200°C (392°F) unless the effects of the time-temperature relationship on the mechanical properties of the pipe are taken into consideration.

b) The depth of the repair cavity, excluding any contribution from the weld bead height, shall be in excess of 1.5 mm (1/16 in.) but shall not exceed 2/3 of the specified wall thickness.

c) The minimum distance of a repair weld from the pipe end shall be 300 mm (12 in.).

d) The minimum distance between any two repaired weld locations shall be 300 mm (12 in.).

e) The length of weld repairs shall not exceed 30% of the specified outside diameter.

f) Back-to-back repairs shall not be permitted.

g) Additional repair to a previously repaired area shall not be permitted.

h) For welds other than circumferential jointer welds, the maximum number of weld repairs in any pipe shall not exceed an average of one weld repair per 3 m (10 ft.) of total weld length, and no weld repair may be repeated.

i) Repairs to defects detected by ultrasonic inspection shall be examined by ultrasonic techniques in addition to film radiographic techniques or non-film radiographic imaging techniques.

Cracks in either the original weld or repair welds are not acceptable, and the area of the pipe containing the crack shall be removed as a cylinder.

8.6.2.2 Repair Welding Procedure Qualification – Additional Tests

8.6.2.2.1 Repair welding procedure qualifications shall be carried out in accordance with the requirements of this Specification, and those outlined in Annex D of API 5L.

8.6.2.2.2 Procedure qualification testing shall also include Charpy impact tests of the weld and heat-affected zone. Energy absorption and shear area requirements shall be in accordance with the requirements of Clause 9.8.3 and Table 9-3 of this Specification. Test temperature shall be as specified in the purchase order. Tests conducted at lower temperatures shall be considered acceptable if the specified absorbed energy requirements are met at the lower test temperature.

8.6.2.2.3 Procedure qualification tests shall include at least two macrohardness traverses across the weld, heat-affected zones and parent metal, as shown in Figure 8-1.

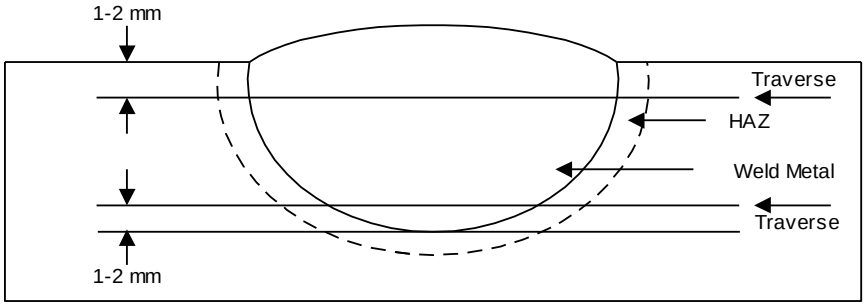


Figure 8-1: Macrohardness Traverse

8.6.2.2.4 Macrohardness testing shall be conducted in accordance with, and shall meet the applicable requirements of, Clauses 8.6.1.5, 8.6.1.6 and 8.6.1.7 of this Specification.

8.6.2.2.5 If the repair welding procedures to be used have not previously been accepted by the Company in writing, they shall be submitted for review and written acceptance by the Company.

8.10 Coil/Plate End Welds

8.10.1.1 Coil/plate end welds (or skelp end welds) shall not be acceptable for finished SAWH pipe unless otherwise specially agreed.

8.11 Jointers

8.11.2 It shall be acceptable to furnish mill jointers, subject to the requirements of Annex A of API 5L and to the requirements of this Specification. Welding shall be completed with the double submerged arc welding process.

8.11.5 Welds containing defects shall be repaired in accordance with the requirements of Clause 8.6.2 of this Specification, or cut out as a cylinder and rejected. Repair of repairs shall not be permitted.

8.11.6 Welding procedures shall meet the requirements of Clause 8.6.1 of this Specification.

8.11.7 Transverse Weld Tensile Tests – Jointer Welds

8.11.7.1 For circumferential mill jointer welds, tests shall be conducted on the first weld and the tenth weld for each diameter and each wall thickness to verify the welding process. Thereafter, tests shall be conducted at a frequency of one test per lot of 500 welds for each diameter and each wall thickness, and shall meet the minimum ultimate tensile strength requirements of Table 7 of API 5L for the applicable pipe grade.

8.11.8 Guided Bend Tests – Jointer Welds

8.11.8.1 For circumferential mill jointer welds, face and root guided-bend tests shall be conducted on the first weld and the tenth weld for each diameter and each wall thickness to verify the welding process. Thereafter, tests shall be conducted at a frequency of one test per lot of 500 welds for each diameter and each wall thickness in accordance with, and to meet the requirements of, Clause 9.7 and Clause 10.2.3.6 of API 5L.

8.11.9 Fracture Toughness Tests – Jointer Welds

8.11.9.1 For circumferential mill jointer welds, tests shall be conducted on the first weld and the tenth weld for each diameter and each wall thickness to verify the welding process. Thereafter, tests shall be conducted at a frequency of one test per lot of 500 welds for each diameter and each wall thickness, and shall meet the requirements of Table 9-3 of this Specification.

8.11.10 Single-Jointers

8.11.10.1 If approved by the Company, it shall be permissible to furnish single-jointers (two pieces welded together to make a length shorter than 15.0 m (49.2 ft.)) to a maximum of 5% of each order item.

8.11.11 Double-Jointers

8.11.11.1 If approved by the Company, it shall be permissible to furnish double-jointers (two pieces welded together to make a length 15.0 m (49.2 ft.) or longer) for an entire order or any portion thereof.

8.11.12 Triple-Jointers

8.11.12.1 If approved by the Company, it shall be permissible to furnish triple-jointers (three pieces welded together to make a length 15.0 m (49.2 ft.) or longer) to a maximum of 5% of each order item.

8.13 Traceability

8.13.2.1 The Quality Assurance program in effect shall provide documentation that allows traceability of the skelp rolling practices, and heat, slab and coil used for each pipe section. If this documentation cannot be supplied, the Company will treat each coil produced during a particular mill work shift as being from a different heat and the frequency of testing shall be increased accordingly.

8.14 Manufacturing Procedure Specification (MPS)

8.14.1 As part of the quotation for the supply of line pipe under this Specification, the Manufacturer shall submit a Manufacturing Procedure Specification (MPS) document providing the information including, but not limited to, that listed in B.3.1 of Annex B of this Specification. The MPS shall be approved by the Company in writing prior to the commencement of production. Any subsequent changes to the approved Manufacturing Procedure Specification shall be approved by the Company in writing prior to implementation.

8.14.2 In addition to the MPS, the Manufacturer shall submit a document that clearly cross-references the locations in the MPS where the requirements outlined in B.3.1 of Annex B and in Clause E.5.8 of this Specification can be found.

9 ACCEPTANCE CRITERIA

9.2 Chemical Composition

9.2.2 Heat analysis and product analysis shall conform to the chemical composition limits specified in Table 9-1 of this Specification. The weight percent for all elements shall be provided to the same number of decimal points as shown in Table 9-1.

Table 9-1: Chemical Composition Limits

		Pipe Grades ≤ L485M (X70M)	Pipe Grades > L485M (X70M)
Element	**Symbol**	**Maximum % (unless a range is specified)**	**Maximum % (unless a range is specified)**
Carbon	C	0.10, see Restriction A	0.10, see Restriction A
Manganese	Mn	1.75 for L415M & L450M, see Restriction A 1.90 for L485M, see Restriction A	2.00, see Restriction A
Phosphorus	P	0.020	0.020
Sulphur	S	0.010	0.008

		Pipe Grades ≤ L485M (X70M)	Pipe Grades > L485M (X70M)
Element	**Symbol**	**Maximum % (unless a range is specified)**	**Maximum % (unless a range is specified)**
Silicon	Si	0.40	0.40
Niobium (Columbium)	Nb (Cb)	0.100 for L360M to L485M, see Restrictions B & C	0.100, see Restrictions B & C
Vanadium	V	0.090 for L360M to L485M, see Restrictions B & C	0.090, see Restrictions B & C
Titanium	Ti	0.004 - 0.030 for L360M to L485M, see Restriction C	0.004 - 0.030, see Restriction C
Aluminum	Al	0.010 min, 0.060 max (ASA†)	0.010 min, 0.060 max (ASA†)
Aluminum	Al	0.020 min, 0.120 max (total†)	0.020 min, 0.120 max (total†)
Nitrogen	N	0.014	0.014
Copper	Cu	0.40	0.40
Chromium	Cr	0.30, see Restriction A	0.30, see Restriction A
Molybdenum	Mo	0.30, see Restriction A	0.40, see Restriction A
Nickel	Ni	1.00	1.00
Calcium	Ca	0.0050	0.0050
Cerium	Ce*	No deliberate additions	No deliberate additions
Boron	B	0.0010, no deliberate additions	0.0010, no deliberate additions
Carbon Equivalent **	CE (*Pcm*)	0.200	0.220

		Pipe Grades ≤ L485M (X70M)	Pipe Grades > L485M (X70M)
Element	**Symbol**	**Maximum % (unless a range is specified)**	**Maximum % (unless a range is specified)**

Notes:

* For facilities not having the capability of analyzing for Ce, it is sufficient to report as "No deliberate additions"

** The carbon equivalent shall be calculated in accordance with the requirements of Clause 9.2.4 of API 5L.

† Either the acid soluble aluminum (ASA) or total aluminum content shall be determined. It is not necessary to determine both values. The minimum limits on Al may be adjusted for Ti-killed and vacuum-degassed steels, in which case an appropriate minimum limit on Ti content will be required instead. Manufacturers wanting to use Ti-killed steels shall clearly identify their intention and proposed Ti limits prior to production.

Restrictions:

Restriction A: See Table 9-2

Restriction B:

V + Nb : 0.12 max for L415M to L690M

Restriction C:

V + Nb + Ti : 0.15 max for L415M to L690M

Table 9-2: Restriction A

Carbon Content	Mn Max for L415M & L450M (X60M & X65M)	Mn Max for L485M (X70M)	Mn Max for >L485M (X70)	(Mn+Cr+Mo) Max for L415M to L485M (X60M to X70M)	Mn+Cr+Mo) Max for L415M to L485M
≥ 0.09	1.50	1.60	1.75	1.95	2.15
0.08	1.55	1.65	1.80	2.00	2.20
0.07	1.60	1.70	1.95	2.02	2.35
0.06	1.65	1.75	1.95	2.07	2.35
0.05	1.70	1.85	2.00	2.20	2.40
≤ 0.04	1.75	1.90	2.00	2.25	2.40

Note:

Carbon values intermediate to those listed (i.e., C=0.085) shall be rounded in accordance to ASTM E29.

9.3 Tensile Properties

9.3.2 The tensile properties shall be as given in Table 7 of API 5L, and as outlined in this Specification.

9.3.2.1 The ratio of yield strength to tensile strength (Y/T) for transverse body tensile tests shall not exceed 0.90 for grades ≤L555M (X80M), and shall not exceed 0.93 for L625M (X90M). The ratio of Y/T shall not exceed 0.93 for L690M (X100M) when testing with flattened strip specimen and shall not exceed 0.95 for L690M (X100M) when testing with other than flattened strip specimen.

9.3.2.2 For transverse weld tensile tests, the ultimate tensile strength shall be as given in Table 7 of API 5L.

9.3.2.3 For transverse weld tensile tests of longitudinal, helical, skelp end and circumferential mill jointer welds, the elongation in 50 mm (2 in.) shall be 10% or more.

9.8 CVN Impact Test for PSL 2 Pipe

9.8.2 Pipe Body Tests

9.8.2.1 Pipe shall be tested at the frequencies specified in Table 18 of API 5L as amended by this Specification, and shall meet requirements outlined in Table 9-3 of this Specification, at or lower than the pipe test temperature specified on the purchase order.

9.8.2.2 For all pipe sizes, the fracture appearance as determined by a Charpy V-notch impact test shall exhibit a fracture appearance shear area of 85% minimum for any test, with no individual test specimen exhibiting less than 75% shear area, at or lower than the test temperature outlined on the purchase order.

9.8.3 Pipe Weld and HAZ Tests

Charpy V-notch impact tests shall be conducted on test specimens taken from the deposited weld metal and heat affected zone, and shall meet requirements outlined in Table 9-3 of this Specification. Samples from longitudinal, helical, skelp-end and circumferential welds, whichever are applicable, shall be selected by the Manufacturer, except that the Company reserves the right to select additional samples. Pipe test temperature shall be the same as that for the notch toughness tests in the body of the pipe.

9.8.3.1 The test frequency shall be the same as required for weld tensile tests.

Table 9-3: Minimum Full Size Charpy V-Notch Absorbed Energy in J (ft. lbs)

		Minimum Full Size Charpy V-Notch Absorbed Energy in J (ft. lbs)[7]			
		Pipe Body		Weld and HAZ	
Overall Design Factor[1]	Pipe Size in mm O.D. (NPS)	Any Heat[2,3]	All Heat Average[2,4]	Longitudinal Seams[5]	Helical, Skelp End, and Circumferential Seams[5]
> 0.60	1219 (48)	75 (55)	155 (114)	75 (55)	55 (41)
> 0.60	1067-1811 (42-46)	65 (48)	145 (107)	65 (48)	50 (37)

		Minimum Full Size Charpy V-Notch Absorbed Energy in J (ft. lbs)[7]			
		Pipe Body		Weld and HAZ	
Overall Design Factor[1]	Pipe Size in mm O.D. (NPS)	Any Heat[2,3]	All Heat Average[2,4]	Longitudinal Seams[5]	Helical, Skelp End, and Circumferential Seams[5]
> 0.60	914-1016 (36-40)	55 (41)	130 (96)	55 (41)	40 (30)
> 0.60	610-864 (24-34)	45 (33)	110 (81)	45 (33)	35 (26)
> 0.60	457-559 (18-22)	40 (30)	90 (66)	40 (30)	30 (22)
> 0.60	406.4 (16)	27 (20)	55 (41)	27 (20)	27 (20)
≤ 0.60	≥ 457-1219 (18 – 48)	40 (30)	55 (41)	40 (30)	30 (22)
≤ 0.60	406.4 (16)	27 (20)	40 (30)	27 (20)	27 (20)

Notes (Normative):

[1] The overall design factor will be specified on the purchase order and the request for quote. In Canada, the overall design factor equals the design factor multiplied by the location factor.

[2] Pipe Body "Any Heat" and "All Heat Average" values are based on specific design conditions, including a grade ≤ L485M (X70M) and a maximum design pressure of 10,000 kPa (1450 psi). If the grade exceeds L485M (X70M) and/or the design pressure exceeds 10,000 kPa (1450 psi), the values shall be re-assessed by the Company and higher values may be specified. Higher values may also be specified for special design conditions (e.g., rich gas or lower design temperatures).

[3] Shear area from Charpy testing shall be reported for pipe larger than 457 mm (NPS 18) for information only.

[4] The "All Heat Average" requirement is recommended, but is not mandatory, for pipe ordered for liquid hydrocarbon pipeline systems and does not apply to pipe for orders filled by the production of less than five heats.

[5] Shear area from the weld and HAZ shall be reported for information only.

[6] The values listed in this Table are suitable for natural gas pipelines designed using the alternate design factors permitted by 49 CFR 192 up to the limits listed in Note 2.

[7] The values in ft. lbs are converted from the values in J.

[8] For pipe wall thickness ≥19.1 mm (0.75 in.), additional testing shall be conducted on mid-wall samples.

9.9 DWT Test for PSL 2 Welded Pipe

9.9.1.1 For pipe larger than 457 mm O.D. (NPS 18), the fracture appearance as determined by a drop-weight tear test shall exhibit a shear area of 85% minimum for any test, with no individual test specimen exhibiting less than 75% shear area, at or lower than the test temperature outlined on the purchase order.

9.10 Surface Conditions, Imperfections and Defects

9.10.4 Laminations

Laminations of any size extending into the face or bevel of the pipe shall be classified as defects. Pipes that contain such defects shall be rejected or cut back until no such lamination is present at the pipe ends.

9.10.5 Geometric Deviations

9.10.5.1 Geometric deviations, other than dents, from the normal cylindrical contour of the pipe (e.g. flat spots and peaks) that occur as a result of the pipe forming process or manufacturing operations, and that exceed 2.0 mm (0.08 in.) in depth or height measured as the gap between the extreme point of the deviation and the prolongation of the normal contour of the pipe, shall be considered defects and treated in accordance with C.3 b) or C.3 c) of API 5L.

9.10.5.2.1 Dents that are 6.4 mm (0.25 in.) or less in depth and contain stress concentrators shall be considered defects and shall be cut out as cylinders and rejected or shall be repaired by grinding to remove stress concentrators, provided that the remaining wall thickness is within the specified limits.

9.5.10.2.2 Dents of any depth that intersect the longitudinal weld seam shall be considered defects and removed from the pipe as a cylinder.

9.10.5.3 Flat Spots and Peaks

9.10.5.3.1 The end of the pipe in the vicinity of the weld shall be checked with a template contoured to check for flat spots and peaks along both the ID and OD, to ensure a maximum deviation of no greater than 2.0 mm (0.08 in.), excluding any out-of-roundness.

9.10.5.4 Belling and Crimping

9.10.5.4.1 The ends of the pipe shall be checked for crimping and belling using a procedure that is accepted in writing by the Company.

9.10.6 Hard Spots

Any hard spot larger than 50 mm (2.0 in) in any direction shall be classified as a defect if its hardness exceeds 300 HV10, based upon individual indentations.

9.10.7 Other Surface Imperfections

Other surface imperfections found by visual inspection shall be investigated, classified and treated in accordance with Clause 9.10.7 of API 5L and as follows:

a) Surface scores (sharp notches, gouges, scores, slivers, pits, etc.) and all stress raising imperfections shall be removed by grinding even though they may be less than the maximum depth permissible for imperfections.

c) Any OD or ID imperfection having a depth that results in a remaining wall thickness at any point of less than 95% of the specified nominal wall thickness shall be considered a defect.

d) The external pipe surface shall be suitable for coating with fusion bond epoxy and polyethylene. Pipe shall have an internal surface suitable for coating with liquid epoxy. Slivers, scabs, bristles or other surface imperfections that would result in an unacceptable applied internal or external coating shall be considered defects and shall be removed by grinding.

9.10.7.1 Grinding

9.10.7.1.1 The minimum remaining wall thickness at any point after grinding shall not be less than 95% of the nominal ordered thickness.

9.11 Dimensions, Mass and Tolerances

9.11.3 Tolerances for Diameter, Wall Thickness, Length and Straightness

9.11.3.1.1 Diameter

9.11.3.1.1.1 Tolerances for diameter of the pipe body and for diameter of the pipe ends shall be in accordance with requirements of Table 10 of API 5L, except that the diameter tolerances shall not exceed plus or minus 2.0 mm (0.08 in.) at any location along the length of the pipe.

Unless otherwise agreed, the diameter of each pipe joint shall be measured at each end (within 100 mm or 4 in.) plus three equally spaced intervals along the pipe body after hydrostatic test.

9.11.3.1.2 Out-of-Roundness

9.11.3.1.2.1 For all pipe sizes and D/t ratios, the maximum difference between the lengths of the major and minor axes at any point along the pipe shall be in accordance with the requirements of Table 10 of API 5L, with the additional requirement that in no case shall the maximum difference between the lengths of the major and minor axes at any point exceed 12.7 mm (0.500 in.).

9.11.3.2 Wall Thickness

9.11.3.2.1 The minimum wall thickness at any location shall be 95% of the specified wall thickness.

9.11.3.2.2 The average wall thickness for the quantity on the purchase order when five or more heats are provided shall not be less than the specified wall thickness. It shall be permissible to establish compliance with this requirement on the basis of mass.

9.11.3.3 Length

a) The minimum length, minimum average length and maximum length shall be identified on the quotation by the Manufacturer and shall be subject to prior agreement by the Company.

9.11.3.4 The tolerances for straightness shall be as per requirements in API 5L and as per the following:

a) The local deviation from a straight line in the 1,000 mm (39 in.) portion at each pipe end shall be less than or equal to 2 mm (0.08 in.).

9.12 Finish of Pipe Ends

9.12.5 Plain Ends

9.12.5.2 Where field welding is to be conducted with other than a mechanized process, pipe shall be furnished with a root face dimension of 1.6 mm (0.063 in.), +0.8 mm (0.031 in.), - 0.0 mm (-0.0 in.) for a minimum of 95% of the circumference around each field end.

9.12.5.2.1 For orders of station pipe, pipe shall be furnished with a root face dimension as per the requirements of API 5L.

9.13 Tolerances for Weld Seam

9.13.1 Radial Offset of Strip/Plate Edges

9.13.1.1 The maximum offset for all wall thicknesses and at any location in the pipe shall be 10% of the specified wall thickness.

9.13.2 Height of the Weld Bead Reinforcement

9.13.2.2 d) The outside weld bead shall not extend above the adjacent pipe surface by more than 3.5 mm (0.138 in.) for specified wall thickness ≤ 13.0 mm (0.512 in.) and 4.0 mm (0.157 in.) for specified wall thickness > 13.0 mm (0.512 in.).

e) For pipe of size 610 mm OD (NPS 24) and larger with an overall design factor greater than 0.50, both ends of the pipe shall have the outside weld reinforcement removed for a distance of at least 150 mm (6.0 in.) from the end of the pipe, such that the outside weld bead does not extend above the outside surface of the pipe by more than 0.1 mm (0.004 in.). The minimum remaining wall thickness at any point after removal of the weld reinforcement shall be in accordance with the requirements of Clause 9.10.7.1 of this Specification.

9.13.4 Offset of Adjoining Lengths of Pipe in Welded Jointers

9.13.4.1 The maximum allowable offset (high-low) between the outside surfaces of adjoining lengths of pipe shall be 2.5 mm (0.100 in.).

9.15 Weldability of PSL 2 Pipe

9.15.1 Weldability tests shall be conducted in accordance with and shall meet the requirements of the *WIC-1 Testing Procedure Specification* in Annex Q of this Specification. Weldability tests are required when the pipe is Grade L415M (X60M) or higher. Weldability tests shall not be required for station pipe orders.

9.15.2 Weldability tests shall be repeated when any of the following conditions occur:

a) the carbon equivalent, calculated in accordance with the requirements of Clause 9.2.4 of API 5L, increases by more than 0.03 from the previously accepted test result

b) the specified wall thickness increases more than 10% within one of the ranges specified in the following note

Note:

There are two wall thickness ranges:

i. < 7.3 mm (0.288 in.)

ii. ≥ 7.3 mm (0.288 in.)

c) the grade increases from the previously accepted test results

d) the steelmaking practice changes

e) the steel Manufacturer or the location of the steel mill changes

f) when a new heat is provided, until a total of three heats have been tested and have been found to meet the requirements of Annex Q of this Specification

9.15.3 Provided that the requirements of Clause 9.15.2 of this Specification are met, successful WIC tests submitted as part of a previous order may be used to satisfy the requirements of a current order.

9.15.4 If more than one of the three test welds in a heat fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected. If one of the three test welds on any heat fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected or two additional test welds from the same heat shall be taken. If either of the two additional test welds fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected.

9.15.5 When a heat is rejected, two additional heats of steel shall be tested. If either of these additional heats is rejected, the acceptance of every heat of steel for the order shall be subject to agreement by the Company.

9.16 Hardness

9.16.1 The maximum macrohardness shall be 280 HV using a load of 10 kg, when conducted in accordance with the requirements of ASTM Standard E92.

10 INSPECTION

10.1 Types of Inspection and Inspection Documents

10.1.3 Inspection Documents for PSL 2 Pipe

10.1.3.1 The Manufacturer shall supply material test and certification documents in a format approved by the Purchaser and in accordance with requirements of this Specification.

10.1.3.2 In addition to the information to be provided in accordance with Clause 10.1.3.2 of API 5L, the following additional information shall also be provided:

b) Chemical composition (heat and product) and acceptance criteria for all elements referenced in Table 9-1 of this Specification, carbon equivalent (heat analysis and product analysis) and acceptance criteria. Additionally, the values of all restrictions listed in Table 9-1 of this Specification shall be reported.

c) Mechanical test results, including results for body tensile tests (including Y/T ratio), transverse weld tensile tests, guided-bend tests, notch toughness tests and macrohardness tests, and heat number and qualification pipe number for each test. For guided-bend tests, it shall be permissible to supply certification that the tests were completed.

d) CVN impact test results, the size, orientation and location of the test pieces; the source (pipe body or weld), type (flattened or unflattened), individual and average test results for each test, heat number and qualification pipe number for each test, and acceptance criteria for each CVN test.

e) DWT test results, type of specimen (flattened or unflattened), type of notch (pressed or chevron), individual and average test results for each test, heat number and qualification pipe number for each test and acceptance criteria for each DWT test.

m) The results of weld zone metallographic examinations (it shall be permissible to supply a certificate that the tests were done in accordance with, and met the requirements of, this Specification in lieu of actual test results).

n) The results of all hardness tests.

o) Steelmaking method, steelmaking practice number, deoxidation practice and casting method.

p) Rolling practice number and the type of skelp rolling mill used.

q) Expansion factor for cold-expanded pipe.

r) Purchase order number.

s) Certification that non-destructive inspection was performed in accordance with, and met the requirements of Clause 10.2.10 of this Specification and Clause 10.2.10 of API 5L.

t) A correlation of heat numbers to pipe numbers for all pipe applied to the order.

u) Certification that the pipe has been manufactured in accordance with the requirements of API 5L and this Specification and/or dual certification to CSA Z245.1, if specified.

10.1.3.3 Pipe shall not be considered for acceptance until two copies of the reports and test certificates required by Clause 10.1.3.2 of this Specification are provided.

10.1.3.4 In addition to the reports and test certificates supplied with the pipe shipments, the final certification documents shall be submitted within two weeks of completion of production. Two paper copies and one searchable electronic copy are required.

10.2 Specific Inspection

10.2.1 Inspection Frequency

10.2.1.2 The inspection frequency shall be as given in Table 18 of API 5L, and as outlined in this Specification.

10.2.1.2.1 Transition Curves

From 5% of the heats supplied for pipe ordered for each diameter, wall thickness and grade, the Manufacturer shall provide and include as applicable with the inspection documents, notch toughness transition curves for pipe body parent material, deposited weld metal and heat affected zone. A minimum of one set of transition curves shall be provided for pipe of each diameter, wall thickness and grade. The documents shall report CVN impact test specimen size, actual test values in tabular form, and shall also include values for absorbed energy and fracture appearance as applicable, plotted in graphical form to clearly illustrate plateau energies and transition temperatures. For orders where the DWT test is a requirement, full transition curves for both shear area (based on DWT data) and energy absorption (based on CVN test data) shall be provided.

Transition curves shall not be required for pipe orders where the specified test temperature is -45 °C, such as station pipe for applications in Canada.

10.2.1.2.2 Hardness Testing

Hardness testing of the deposited weld metal, heat affected zone and parent material shall be performed on prepared cross-sections at locations as outlined in Clause 8.6.1.5 of this Specification. Test frequencies shall be as follows:

a) For longitudinal and helical welds: one test per production welding day per OD welder, and at least once for each heat of material supplied for an order.

b) For skelp end welds: one test per 50 lengths containing skelp end welds.

c) For circumferential mill welds: one test per lot of 500 welds.

Tests shall be conducted in accordance with the requirements of Clause 9.16.1 of this Specification.

10.2.3 Samples and Test Pieces for Mechanical Tests

10.2.3.1.1 Samples and test pieces for mechanical tests (tensile tests, CVN tests and DWT tests) that are conducted at the frequency specified in Table 18 of API 5L and

Clause 10.2.1 of this Specification shall be taken from the same end of the same length of pipe that is sampled for testing.

10.2.3.2 Test Pieces for Tensile Test

10.2.3.2.1 The use of round test specimens shall be restricted to Grade L555M (X80M) and higher, and shall be subject to agreement by the Company.

10.2.3.2.2 Weld reinforcement shall not be removed from weld tension test specimens.

10.2.4 Test Methods

10.2.4.2.1 For pipe weld tests, the percentage elongation after fracture shall be determined.

10.2.6 Hydrostatic Test

10.2.6.1 The test pressure shall be held constant for a duration of not less than 10 seconds.

10.2.6.2.1 The individual pressure recordings shall be unambiguously traceable to each pipe number and heat number.

10.2.6.5.1 The pressure of the hydrostatic test medium shall stress the pipe wall to at least 95% of the Specified Minimum Yield Strength (SMYS).

10.2.6.6 Any proposals to determine test pressure by applying end load compensation in accordance with Equation (7) of API 5L shall be indicated at the time of submission of proposals for supply. The hoop stress induced by the hydrostatic pressure as calculated by Equation (6) of API 5L (i.e., without end load compensation) shall be at least 90% SMYS.

10.2.6.7 The required test pressure shall be determined using the specified nominal wall thickness, *t*.

10.2.6.8 Hydrostatic gauges are to be calibrated prior to commencement of production of pipe of each diameter, wall thickness and grade, at least weekly thereafter, and after all hydrostatic test failures.

10.2.6.9 Each hydrostatic test failure shall be investigated, and the cause of each failure determined and fully documented. The failure investigation results shall be forwarded to the Company. This requirement shall not apply if the pipe being hydrostatically tested was rejected prior to the hydrostatic test.

10.2.7 Visual Inspection

10.2.7.1 All pipe shall be subjected to visual inspection over the entire internal and external surfaces in accordance with requirements of Clause 10.2.7.1 of API 5L and also in accordance with Clause 10.2.7.1.2 of this Specification.

10.2.7.1.1 The external and internal surfaces of the pipe shall be presented for final visual inspection free of oil, grease, lubricant, flux, loose mill scale or other foreign matter.

10.2.7.1.2 Visual inspection shall include, but not be limited to, the following:

a) The entire external surface by an inspector walking the full length of the pipe.

b) The internal surface by an inspector crawling the pipe, except that pipe smaller than 762 mm OD (NPS 30) may be internally inspected from the ends using suitable inspection lamps.

c) The pipe ends.

10.2.8 Dimensional Testing

10.2.8.3 For pipe larger than 457 mm OD (NPS 18), it shall be permissible for the tolerances on outside diameter of the pipe to be applied to the inside diameter.

10.2.10 Non-Destructive Inspection

Non-destructive inspection shall be in accordance with Annex E of both API 5L and this Specification.

10.2.12 Retesting

10.2.12.6 Charpy retests

10.2.12.6.1 For CVN impact tests on pipe welds and heat affected zones, failure of any test shall require two additional tests; one on the pipe immediately before the failed pipe and the second on the pipe immediately after the failed pipe. The pipe tested shall be from the same OD welding station and have been welded using the same welding procedure. If both tests conform to the requirements, the pipe in the lot shall be accepted, except that pipe from which the initial test was taken. If one or both tests fail to meet the requirements, all pipe in the lot shall be individually tested and each pipe shall meet the specified requirements or the Manufacturer may reject the lot. To qualify the original failed pipe, if both retests pass, the Manufacturer shall take an additional test from each end and the specified requirements shall be met.

10.2.12.7 Hardness retests

10.2.12.7.1 In the event of a hardness test failure, a documented proposal for the location and number of retests shall be prepared by the Manufacturer and submitted for approval by the Purchaser.

10.2.12.7.2 The results of all hardness tests shall be reported.

11 MARKING

11.2 Pipe Markings

11.2.1 Pipe markings shall include the following information in addition to that required by Clause 11.2 of API 5L, and when specified, in addition to that required by Clause 15.2 of CSA Z245.1, latest revision:

k) the pipe number as applied to the ID and OD of each pipe at both ends

l) the heat number (or code traceable to the heat number) as applied to the I.D. at both ends of each pipe

m) the purchase order number as applied to the ID and OD at both ends of each pipe

n) for mill-jointers, the following marking as applied to the ID and OD of each jointed section at both ends:

- Top line: jointer segment pipe no. nearest observer
- Middle line: middle jointer segment pipe no., if applicable
- Bottom line: jointer segment pipe no. farthest away from observer.

11.2.3 Die-stamping and/or vibro-etching shall not be permitted on the inside or outside surface of the pipe.

11.2.4 If agreed, the pipe markings as required on the OD of the pipe may be applied after subsequent coating application. In such case, the pipe markings on the ID of the pipe, as required per this Specification and approved for the project, shall be completed before coating application and traceability shall be ensured.

11.2.8 Additional markings applied shall be at the approval of the Company.

11.2.9 All markings required by API 5L, the purchase order number, heat number (or code traceable to the heat number) and pipe number shall be marked on the inside and/or outside surface of the pipe in accordance with Table 11-1 of this Specification.

Table 11-1: Location of Markings

Pipe Size in mm O.D. (NPS)	API Marking and Heat Code	Pipe	PO Number
All sizes	ID	ID and OD	ID and OD

The heat code, purchase order number and pipe number shall be placed at both ends of each length of pipe.

Figure 11-1 and Table 11-2 of this Specification provide further detail on where markings should be placed.

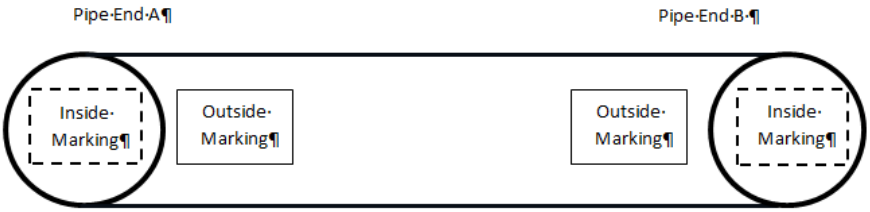


Figure 11-1: Location of Pipe Markings

Table 11-2: Specific Location of Pipe Markings

Pipe Size in mm O.D. (NPS)	Pipe End A		Pipe End B	
	Outside Marking	Inside Marking	Outside Marking	Inside Marking
All sizes	1. Pipe Number 2. PO Number	1. API 5L Clause 11 requirements 2. Pipe Number 3. PO Number	• Pipe Number • PO Number	1. Heat Code 2. Pipe Number 3. PO Number

12 COATINGS AND THREAD PROTECTORS

12.1 Coatings and Linings

12.1.1 Unless otherwise stated on the purchase order, pipe shall be supplied with bare metal finish.

15 ADDITIONAL DOCUMENTATION REQUIREMENTS

15.1 Documentation Requirements

15.1.1 The Manufacturer shall submit to the Company, the following documents within the time period shown:

a) Weldability test results no later than the cargo shipment readiness date (see Clause 9.15 of this Specification).

b) Qualified Welding Procedure Specifications (WPS) with the supporting Procedure Qualification Records (PQR) or a change to such procedures production no later than the cargo shipment readiness date (see Clauses 8.6.1 and 8.6.2 of this Specification).

c) Where applicable and specified, the stress relieving heat treatment qualification test results no later than the cargo shipment readiness date (see Clause 8.3.10 of this Specification).

d) Number of meters (or feet) shipped and number of pipe lengths shipped within five working days after each shipment.

e) For orders of 10 heats or more, product histograms for each of the items listed in Table 15-1 shall be supplied within one month after the completion of production. The minimum, maximum, arithmetic mean (average), median value, number of samples and standard deviation shall be reported clearly either in the histograms or separately. For Items 1 to 15 in Table 15-1, histograms shall be prepared for both the heat analysis and product analysis.

Table 15-1: Items Requiring Product Histogram Documentation

1. Carbon Equivalent	13. Titanium
2. Carbon	14. Aluminum
3. Manganese	15. Nitrogen
4. Silicon	16. Transverse Yield Strength
5. Sulfur	17. Transverse Tensile Strength
6. Phosphorus	18. Yield/Tensile Ratio (Y/T)
7. Copper	19. Transverse Weld Tensile Strength
8. Nickel	20. CVN Absorbed Energy - pipe body
9. Chromium	21. CVN Shear Area - pipe body*
10. Molybdenum	22. DWTT Shear Area - pipe body
11. Vanadium	23. CVN Absorbed Energy - weld metal
12. Niobium	24. CVN Absorbed Energy - HAZ
*As applicable	

f) In addition to the reports and test certificates supplied with the pipe shipments, the final certification documents shall be submitted within two weeks of completion of production. Two paper copies and one non-modifiable searchable electronic copy are required.

15.2 Pre-Production Documentation Requirements

15.2.1 The Manufacturer shall supply the Company, at the time of quotation, with any exceptions or alternatives to this Specification. The minimum length, minimum average length and maximum length shall be identified at the time of quotation by the Manufacturer. In addition, the centerline segregation acceptance level shall be presented.

15.2.2 The Manufacturer shall supply the Company, at the time of quotation, a Manufacturing Procedure Specification (MPS) (see Clause 8.14 of this Specification).

15.2.3 Prior to the commencement of production, the Manufacturer shall submit, or have previously submitted, to the Company the following documents and shall have received written acceptance of such from the Company:

a) Ultrasonic inspection procedures for the skelp or pipe body (see Clause 8.3.2.3 of this Specification).

b) Ultrasonic inspection procedure for the weld (see Clause E.5.8 of this Specification).

c) Radiographic inspection procedures for welds (see Annex E of API 5L).

d) If applicable, an alternative method of measuring flat spots and peaks (see Clause 9.10.5.3 of this Specification).

e) The procedure for measuring crimping and belling (see Clause 9.10.5.4 of this Specification).

f) If applicable, an alternative procedure for removing markings identifying imperfections (see Clause E.3.5.1 of this Specification).

g) Liquid penetrant, magnetic particle or ultrasonic inspection procedures, whichever are applicable, for the pipe ends (see Clause E.3.4.1 of this Specification).

15.2.4 The Manufacturer shall inform the Company in writing of any changes to the above documents and shall obtain the written acceptance of the Company for such changes prior to implementing the changes.

15.2.5 The Manufacturer shall have written procedures for the loading, shipping and storage of pipe. These procedures are to be made available to the Company on request.

16 PURCHASER INSPECTION

16.1 The Manufacturer shall allow free access by the Company or its representative to all steelmaking and rolling mill facilities providing skelp for the pipe order.

16.2 The Company may arrange under separate contract with one or more third-party agencies to conduct supervisory, visual, mechanical, electromagnetic, ultrasonic or other types of inspection in the pipe mill.

16.3 Where requested by the Company, the Manufacturer shall permit the examination of all test records made as a production control during the manufacture of the skelp or pipe.

17 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are listed in Table 17-1, Table 17-2 and Table 17-3. Use the latest document revision, unless otherwise approved by TransCanada.

Table 17-1: Regulatory References

Organization/Document No.	Title
National Energy Board (NEB)	SOR/99-294, *National Energy Board Onshore Pipeline Regulations (NEB OPR)*
NOM-007-SECRE	*Transporte de Gas Natural*
U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) Code of Federal Regulations (CFR)	Title 49 Part 192, *Transportation of Natural Gas by Pipeline: Minimum Safety Standards*
	Title 49 Part 195, *Transportation of Hazardous Liquids by Pipeline*
Various	Other applicable federal, provincial and territorial safety acts and regulations by the authority having jurisdiction

Table 17-2: External Industry References

Organization/Document No.	Title
American Petroleum Institute (API)	5L, *Specification for Line Pipe*
	1104, *Welding of Pipelines and Related Facilities*
American Society for Testing and Material (ASTM)	E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*
	E92, *Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials*
American Society of Mechanical Engineers (ASME)	B31.4, *Pipeline Transportation Systems for Liquids and Slurries*
	B31.8, *Gas Transmission and Distribution Piping Systems*
	BPVC-IX, *Welding and Brazing Qualifications*
Canadian Standards Association (CSA)	Z245.1, *Steel Pipe*
	Z662, *Oil and Gas Pipeline Systems*

Table 17-3: Internal References

Document No.	Title
For this Specification, there are no specific Internal references.	

18 DOCUMENT HISTORY

Rev.		
04	**Description**	**Effective Date**
	Revised document developed as part of Columbia Pipeline Integration.	2017-Aug-01
	Rationale Statement	**Responsible Engineer**
	This document was revised to address the following requirements: • Integration of Columbia Pipeline requirements.	Jessica de Vries, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group, to integrate Columbia Pipeline requirements, and to make it more easily accessible to those who use it.	Jessica de Vries, P. Eng.
03	**Description**	**Effective Date**
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	**Responsible Engineer**
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Jessica de Vries, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group and to make it accessible to those who use it.	Jessica de Vries, P. Eng.

19 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
N/A	This Specification was updated and put into the new template. Changed name from TES-PIPE-SAW to TES-MA-SAWPI-GL following the new naming convention.

20 APPROVALS

APPROVALS		
Originator: Derek Chen, P. Eng. Welding and Materials Engineering	Signature	Date: June 26, 2017
Reviewer: Cindy Guan, P. Eng. Welding and Materials Engineering	Signature	Date: June 26, 2017
Reviewer: Jaclyn Brown, P.E. USGO Integrity Program Services	Signature	Date: 6/27/2017
Responsible Engineer: Jessica de Vries, P. Eng. Welding and Materials Engineering	Signature Date: June 26, 2017	APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, P. Eng., Manager Welding and Materials Engineering	Signature	Date: June 26, 2017

ANNEX B MANUFACTURING PROCEDURE QUALIFICATION FOR PSL2 PIPE

B.3.1 Manufacturing Procedure Specification (MPS) Requirements

The Manufacturing Procedure Specification (MPS) submitted shall include, at a minimum, the following detailed information:

a) steel source, including steelmaking method, heat size, deoxidation practice, inclusion shape control practices, and casting method

b) aim chemistries, including minimum and maximum limits for intentionally added elements, and maximum limits and typical contents for residual elements, for all elements referenced in Clause 9.2 of this Specification at least, and as applicable to pipe of each diameter, wall thickness and material grade to be made for the order

c) superheat for continuous casting, tundish weight, caster diameter, mold type, cast sequence length, intermix practice between different steel chemistries, typical cast speed for types of line pipe products ordered

d) slab soundness and centerline segregation control, system of segregation rating, sample location in the cast sequence and sampling frequency, sample orientation & size, etching method and acceptance criterion for specific products of the order

e) disposition of 1st and last slab in cast sequence for line pipe products, slab inspection and conditioning, and slab dimensions used for specific products of the order (for plate and/or coil)

f) skelp rolling source, specific rolling and forming practices, including where applicable, typical reduction schedules and associated temperature control ranges, controlled rolling start thicknesses and temperatures, final finishing temperatures, coiling temperatures or accelerated cooling stop temperatures, and facilities for thermo-mechanical controlled rolling and on-line accelerated cooling

g) skelp inspection procedures as applicable

h) details of pipe forming procedures

i) pipe manufacturing location, and any plant limitations on wall thickness, diameter, and material grade

j) typical welding parameters and consumable combinations applicable to longitudinal, helical, skelp end, repairs and circumferential welds

k) a description of the quality organization applicable to steelmaking, casting, skelp rolling and pipe manufacturing facilities, including identification of reporting practices, verification mechanisms to assure product traceability in accordance with the requirements of API 5L, and responsibility for customer contact related to commercial and quality matters

l) a flow chart for pipe manufacturing, finishing and qualification processes

m) normal mill control tolerances, assessment and recording frequencies for all specification dimensions for pipe

n) laboratory test equipment present at the manufacturing plant for testing of material properties for the order

o) all non-destructive inspection procedures utilized for specification compliance and for production control, as applicable to skelp, pipe body and welds

p) method and typical amount of cold expansion, as applicable

q) yard handling, storage and shipping procedures, including drawings of proposed methods of stacking and securing pipe for shipment and method of end protection

r) order-specific Inspection and Test Plan (ITP) for Company review and approval

ANNEX E NON-DESTRUCTIVE INSPECTION FOR OTHER THAN SOUR SERVICE OR OFFSHORE SERVICE

E.1 Qualification of Personnel

E.1.1 ISO 9712 shall be the basis for the qualification of non-destructive inspection personnel (excluding visual inspection). Such personnel shall be re-qualified for any method previously qualified if they have not performed non-destructive inspection in that method for a period exceeding 12 months.

E.1.2 Non-destructive inspection shall be conducted by Level 2 or 3 personnel.

E.1.3 Evaluation of indications shall be performed by Level 2 or 3 personnel.

E.3 Methods of Inspection

E.3.1.4 Longitudinal and helical weld seams shall be inspected for longitudinal and transverse imperfections by an ultrasonic method, or by a combination of ultrasonic and radiographic methods. The complete volume of weld metal and heat-affected zones in the weldment shall be inspected, including the mid-wall for radial imperfections.

E.3.1.5 Skelp end welds shall be inspected for longitudinal and transverse imperfections by an ultrasonic method, a radiographic method, or a combination of ultrasonic and radiographic methods, in accordance with the requirements of API 5L and this Specification. Procedures shall be approved by the Purchaser.

E.3.1.6 The junctions of skelp end welds and helical seam welds (T-joints) shall be inspected by procedures including film radiographic methods approved by the Purchaser.

E.3.1.7 Repair welds shall be inspected by radiographic methods in accordance with Clause E.4 of Annex E of API 5L, or by ultrasonic inspection where required by Clause 8.6.2.1 (i) of this Specification.

E.3.1.8 Circumferential jointer welds produced by double submerged arc welding shall be inspected for longitudinal and transverse imperfections by radiographic methods in accordance with Clause E.4 of Annex E of API 5L, by ultrasonic methods in accordance with requirements of API 5L and this Specification, or by a combination of radiographic and ultrasonic methods. Standards of acceptability for circumferential jointer welds shall be in accordance with the requirements of the latest edition of API 1104.

E.3.1.9 The junctions of jointer welds and other double submerged arc welds shall be inspected by radiographic methods, or by ultrasonic inspection methods approved in writing by the Company. Standards of acceptability for the junctions of jointer welds and other double submerged arc welds shall be in accordance with the requirements of Clause E.4 of Annex E of API 5L, or Clause E.5.5.1.1 of this Specification, whichever is applicable.

E.3.1.10 Ultrasonic inspection of helical and longitudinal weld seams shall be performed after final hydrostatic testing.

E.3.1.11 Fluoroscopic inspection shall not be accepted for Specification compliance in the inspection of the skelp end welds, repair welds, circumferential jointer welds or the junctions of jointer welds.

E.3.4 Pipe End Bevel Inspection

E.3.4.1 The bevel area of all pipe shall be inspected for laminations by an ultrasonic inspection technique. Alternatively, the root face and bevel shall be inspected for laminations by a liquid penetrant or a magnetic particle technique after beveling. The inspection procedure shall be documented and accepted by the Company prior to production.

E.3.5 Removal of Markings

E.3.5.1 Any paint markings applied to the pipe to mark locations where alarm limits were exceeded, or where imperfections were noted, shall be removed or painted over with black paint, after it has been confirmed that a defect is not present. The Manufacturer may submit an alternative procedure for acceptance by the Company in writing if this requirement deviates from their standard practice.

E.4 Radiographic Inspection of Welds

E.4.2.2 The radiographic films used shall be in accordance with ISO 11699-1:2008, class C4 or better or ASTM E1815-08, class I, and shall be used with lead screens.

E.5 Ultrasonic and Electromagnetic Inspection

E.5.2 Ultrasonic and Electromagnetic Inspection Reference Standards

E.5.2.3.1 Reference standards for standardization and inspection sensitivity checks shall contain machined standardization reflectors as follows:

a) 1.6 mm (0.063 in.) radially drilled hole or transverse notch (5.0% of specified wall thickness), in accordance with Table E.7 of API 5L, for application of acceptance limits and for setting of alarm levels applicable to transverse defect inspection

b) 1.6 mm (0.063 in.) radially drilled hole, in accordance with Table E.7 of API 5L, for application of acceptance limits and for setting of alarm levels applicable to longitudinal defect inspection

c) rectangular notches; ID and OD, longitudinal orientation, depth 5.0% of specified wall thickness, dimensional tolerances as specified in Table E.7 of Annex E of API 5L, for the verification that the sound beam for longitudinal defect inspection is being directed perpendicular to the weld line

d) at the start of production, the detection of mid-wall imperfections shall be proven using a 2 mm (0.08 in.) diameter mid-wall standardization reflector

E.5.3 Instrument Standardization

E.5.3.1.1 Any signal suppression and electronic damping implemented for standardization shall be identical to that implemented for inspection of the pipe during production.

E.5.3.1.2 Standardization shall be performed at the start of production, after the inspection sensitivity checks required by Clause E.5.4.1.1 of this Specification, and at the start of inspection after any shutdown of the ultrasonic inspection equipment during production. The inspection equipment shall be adjusted to obtain, from the applicable reference standards used to establish the acceptance limits, signals that are within the gate width and exceed the alarm limit, when the reference standard is scanned in a manner duplicating inspection in the dynamic mode.

E.5.3.1.3 The gate start locations and gate widths shall be validated during calibration by positioning the search units at locations coincident with the extremes of the tracking error, and producing signal amplitude at or above the alarm limit signal produced from the standardization reflector.

E.5.4 Records Verifying System Capability

E.5.4.1 Inspection Sensitivity Checks

E.5.4.1.1 The inspection sensitivity shall be checked at least twice every working shift, prior to any planned shutdown of the ultrasonic equipment during production and at the end of production, using the reference standard containing the machined calibration reflectors specified in Clause E.5.2.3.1. For inspection sensitivity checks, the reference standard shall be run through the ultrasonic equipment at production speed.

E.5.4.1.2 Where the signal obtained from the standardization reflector is more than 3dB lower than the acceptance limit, all pipe inspected after the preceding acceptable standardization shall be re-inspected after re-standardization has been accomplished.

E.5.5.1.1 Acceptance Limits

For inspection of the pipe welds, any imperfection that produces a signal greater than the applicable acceptance limit signal for the applicable radially drilled hole or transverse notch shall be considered to be a defect, and shall be dispositioned in accordance with Clause C.4 of Annex C of API 5L and Clause 8.6.2 of this Specification.

E.5.8 Non-Destructive Inspection Procedure Documentation

All non-destructive final inspection procedures, other than for electromagnetic inspections, shall be submitted to and shall receive written acceptance by the Purchaser prior to implementation.

An ultrasonic procedure shall be submitted to the Purchaser for review and written acceptance prior to the start of production. The procedure shall include, but not be limited to, the following information as applicable to both the production-speed inspection system and to any system used for manual prove-up of noted imperfections:

a) ultrasonic instrument equipment manufacturer(s) and model number(s)

b) standard for verification of linearity as performed on instrumentation

c) a drawing clearly outlining the number of ultrasonic transducers in the system, and the location and position of all of the transducers

d) for each transducer or transducer set in the system, gate width setting for dynamic-mode inspection

e) a drawing clearly outlining the identified area of inspection for each transducer when using the gate settings noted above

f) a drawing or statement clearly outlining the maximum tracking error

g) a drawing clearly outlining the design of the reference standard, with details of the location and orientation of holes and surface notches used for standardization

h) for each of the respective reference indicators, the alarm limit settings applied for each of the applicable transducers or transducer sets

i) the mode of operation of each transducer or pair of transducers (pulse echo, transmit only, or receive only)

j) coupling medium utilized for the system

k) coupling alarm method

l) the shape and dimensions of each transducer

m) nominal search unit frequency for each transducer

n) sound entrance angle for each transmitting transducer

o) pulse repetition rate for each transducer or transducer set

p) maximum production-speed of pipe through the system

q) the marking device utilized and if applicable, the marking method and location of marking on the pipe as related to imperfection location

r) standardization procedure, including frequency for standardizations

s) sensitivity check procedure, including frequency for sensitivity checks

E.7.6 Four readings shall be taken approximately 90° apart around the circumference of each end of the pipe. The average of the four readings shall be ≤ 2.5 mT (25 Gauss), and no one reading shall exceed 3.0 mT (30 Gauss) when measured with a Hall-effect gaussmeter or equivalent values when measured with another type of instrument.

ANNEX Q WIC – 1 – TESTING PROCEDURE SPECIFICATION

Q1.0 SCOPE

Q1.1 This Specification defines the procedures and acceptance criteria for the evaluation of the weldability of line pipe material using the modified WIC test. The modified WIC test is a single pass restrained groove weld produced with cellulosic electrodes and it is used to evaluate the material's susceptibility to hydrogen cracking.

Q1.2 This Specification is applicable to the qualification of carbon and low-alloy steel pipe material.

Q2.0 TESTING PROCEDURE

Q2.1 Test Assemblies

The materials required to fabricate the test assembly shown in Figure Q-1 are listed in Table Q-1. Each assembly shall be fabricated as follows:

The stiffener plate shall be welded to the bottom of the backing plate to prevent joint rotation. The shims shall be located beneath the test sections (Figure Q-2) and the test sections shall be fillet welded to the backing bar with a root gap of 1.5 mm ± 0.5 mm (typical). The restraint fillet welds shall be made using a low hydrogen process and welding shall proceed outwards relative to the weld joint preparation, see Figure Q-3. A distance of 25 mm ± 0.5 mm, centered over the weld joint preparation, shall not be welded to the backing bar, and this constitutes the restraint length. Run-on and run-off tabs shall be used to ensure uniform weld deposition within the test weld. The run-on and run-off tabs shall be tack-welded to the backing plate only.

Q2.2 Number of Test Welds and Preheat

For each heat of steel, a minimum of three acceptable test welds shall be evaluated to determine the cracking percentage at the preheat temperature given in Table Q-2.

Q2.3 Welding Technique

Q2.3.1 All welding shall be performed in the vertical down direction with the test assembly located vertically (ASME Section IX 3G position). Welding can be performed manually; however, extensive practice may be required to achieve uniform travel speeds.

Q2.3.2 Test assemblies shall be uniformly heated in an oven to a temperature slightly higher than the desired preheat temperature. The assembly shall be removed from the oven and the temperature at the bevels monitored using a contact thermocouple. Welding shall begin as the required preheat given in Table Q-2 is reached.

Q2.3.3 Welding shall be performed with the consumables given in Table Q-2.

Q2.3.4 Welding parameters shall be monitored using external instrumentation for all tests. The combination of welding parameters shall be such that the resulting heat input is within the range given in Table Q-2.

Q2.4 Acceptable Test Weld Workmanship

Q2.4.1 WIC test welds shall have a profile that is typical of the cellulosic root bead used for pipeline welding (see Figure Q-4). The weld shall be free of significant geometric flaws which will include the following workmanship discontinuities:

a) incomplete penetration of the root bead

b) incomplete fusion of the root bead

c) porosity and hollow bead

d) coupon misalignment (high-low)

e) weld metal centerline solidification cracks

Q2.4.2 The test weld will be sectioned in accordance with the requirements of Clause Q2.5. The minimum weld throat thickness for each section shall be as given in Table Q-2. Unless the section is free of cracks, variation in the WIC test weld throat thickness for each section shall not exceed twice the actual throat thickness (depth of weld h_w, Figure Q-4). Should any of the examined sections fail to meet the workmanship requirements, the entire weld shall be discarded and replaced with another WIC test weld that meets the workmanship requirements.

Q2.5 Measurement of Total Crack Percentage

The test welds shall be allowed to cool to room temperature and removed from the backing bar 24 hours after welding. If complete cracking occurs through the test weld, the total cracking percentage is 100%. If complete cracking through the weld does not occur, the weld shall be sectioned and examined microscopically for cracking. The weld shall be sectioned at the 1/4, 1/2 and 3/4 positions as shown in Figure Q-4. Faces 1A, 2A, 2B and 3B shall be polished, etched and examined at a magnification, of 100X. The depth of cracking, h_c, and the depth of the weld (actual throat thickness) h_w, shall be determined for each section and the total cracking percentage for each test weld reported as follows:

$$\frac{\sum h_c}{\sum h_w} \times 100$$

Q3.0 ACCEPTANCE CRITERIA

Q3.1 Total Cracking Percentage

No single test weld shall result in a total cracking percentage exceeding the value given in Table Q-2.

Q4.0 REPORTING

A final report shall be completed for each weldability evaluation. The report, to include all the test welds completed for the evaluation, shall contain the following information:

a) material description

b) diameter, wall thickness and grade of the pipe tested

c) heat number

d) steelmaking practice (as identified by a unique practice number), steel manufacturer and location of steel mill

e) mill test chemistry

f) consumable brand name, consumable manufacturer's traceability number (heat number, batch number or both) and the electrode diameter

g) weld parameters (amps, volts, travel speed, and heat input) and preheat

h) crack dimensions and bead dimensions

i) summary of test results

j) test personnel names

k) date and number of report

l) signed certification

Table Q-1: Test Assembly Material Dimensions

Quantity	Material	Dimensions			Comments
		Thickness, t (mm)	Width, w (mm)	Length, l (mm)	
2	Test sections, (material under evaluation)	Thickness to be tested	50±1	150±5	One end prepared with standard bevel of pipe specification and oriented such that the actual test weld is deposited perpendicular to the plate/coil rolling direction or to the longitudinal axis of the pipe.
1	Backing plate, mild steel	19 min.	75 min.	300 min.	
1	Stiffener plate, mild steel	19 min.	75 min.	300 min.	
2	Backing shims, steel	3 min.	50 + 1, -10	140 +1, -20	
2	Run on/off tabs, steel	3 min.	19±5	25 min.	Same thickness as backing shim

Table Q-2: Testing Requirements

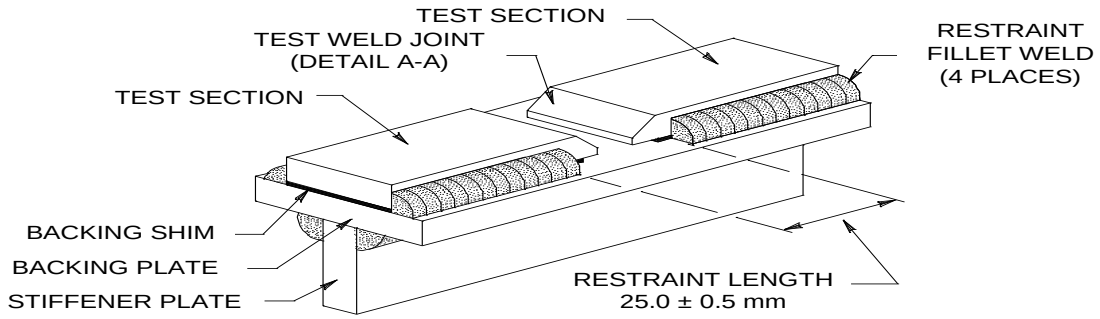
Testing Requirements[2]	Test Sample Nominal Thickness (mm)	
	< 7.3	≥ 7.3
Preheat Temperature (°C)	60±1	75±1
Electrode Classification	E55010-G (E8010-P1)[1]	E55010-G (E8010-P1)[1]
Electrode Diameter (mm)	3.2	4.0
Heat Input (kJ/mm)	0.55 - 0.65	0.65 - 0.75
Typical Welding Parameters	100 - 125 A 23 - 25 V 300 mm/min.	130 - 140 A 22 - 24 V 300 mm/min.
Minimum Weld Throat Thickness of each Section (mm)	2.0	2.5
Maximum Allowable Total Cracking Percentage (%)	5	3

Note(s):

[1] Approved electrodes: Phoenix Cel-80, Lincoln 70+, Bohler Fox Cel 85

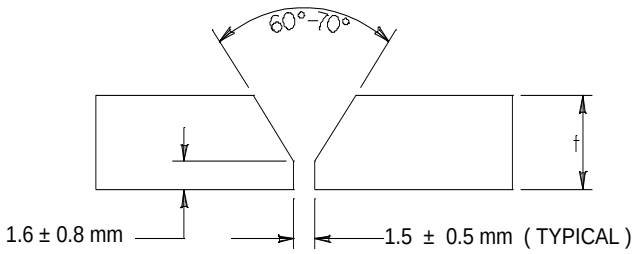
[2] The same supplier, and consumable manufacturer's traceability number (heat number, or batch number or both) shall be used for a series of tests.

CAUTION: Discretion is advised to the Manufacturer and/or test lab that the use of aged electrodes may affect test results.



NOTE:

1. SEE TABLE 1 FOR DIMENSIONS NOT SHOWN.
2. RUN ON/OFF TABS (NOT SHOWN) SHALL BE TACK WELDED TO BACKING PLATE ONLY.
3. BACKING SHIMS ARE PLACED BETWEEN TEST PLATES AND BACKING PLATES.



Test Weld Joint - Detail A-A

Figure Q-1: Modified WIC Test Assembly

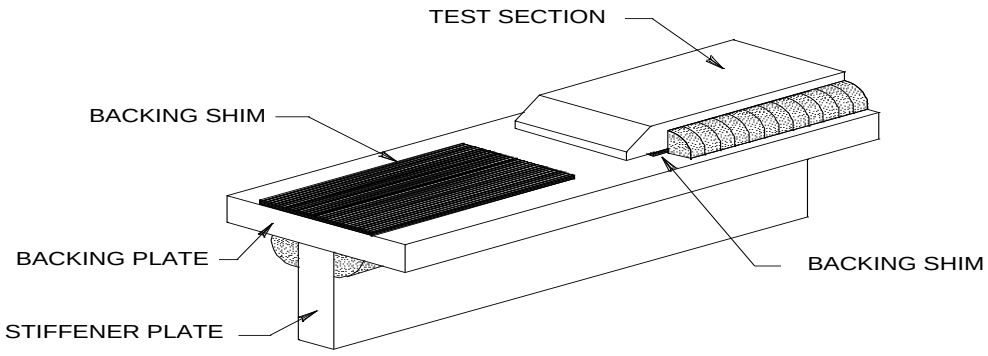


Figure Q-2: Backing Shim Location

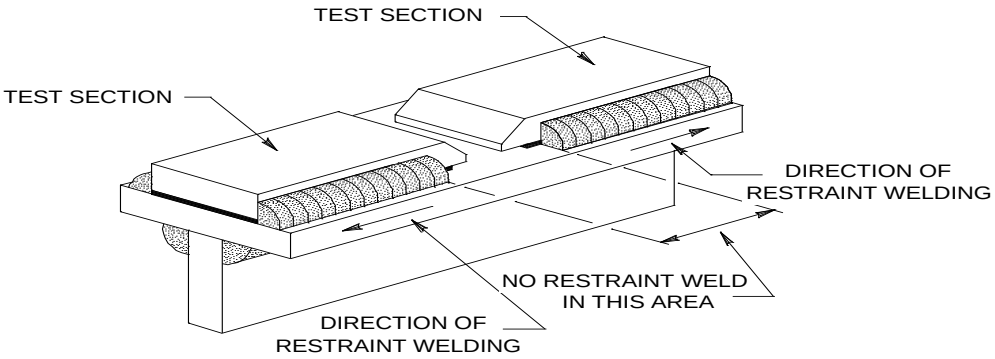
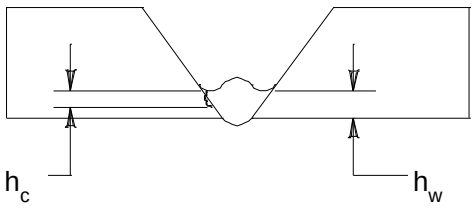
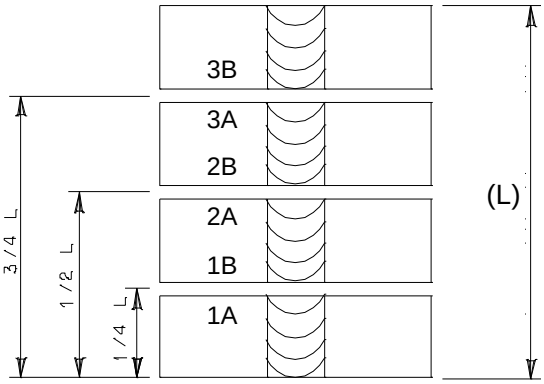


Figure Q-3: Test Section and Restraint Weld Location





NOTE:

1. TEST WELD BEAD SHALL EXHIBIT COMPLETE ROOTPENETRATION AND FUSION.
2. IF h_w IS DIFFERENT ON THE 2 SIDES OF THE WELD USE THE MINIMUM VALUE.
3. (L) - TEST WELD LENGTH
4. h_w- DEPTH OF WELD
5. h_c- DEPTH OF CRACKING

Figure Q-4: Weld Specimen Sectioning

ANNEX R TESTS FOR SUSCEPTIBILITY OF PIPE TO STRESS RELIEVING

R1.0 A sample of pipe shall be stress relieved between 593°C (1100°F) and 649°C (1200°F) for a minimum holding time of 1 hour per 25 mm (1 hour per inch) of thickness, but not less than 1 hour. The temperature shall be recorded on the report supplied to the Company.

R2.0 The same mechanical tests that are required on the pipe that has not been stress relieved shall be conducted on the pipe that has been stress relieved.

R3.0 A report shall be prepared comparing the results of the stress relieved tests to those of the non-stress relieved tests.

Note:

This testing is for information only. The mechanical properties of the stress-relieved pipe may be higher or lower than the non-stress relieved pipe.

R4.0 The tests shall be repeated when there is a change in the steelmaking practice or when pipe of a thicker nominal wall thickness is supplied.

ANNEX S ADDITIONAL DESIGN REQUIREMENTS FOR STEEL PIPE USING ALTERNATIVE MAXIMUM ALLOWABLE OPERATING PRESSURE IN THE USA (AND MEXICO)

S1.0 SCOPE

Natural gas pipelines designed to operate with design factors in excess of those listed in §192.111 of 49 CFR 192 shall meet all of the requirements of this Specification, and the additional requirements of §192.112 of 49 CFR 192 and any amendments or errata issued by the U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration.

This annex outlines the requirements under §192.112 of 49 CFR 192 that are not accounted for in the other Clauses of this Specification.

S2.0 ADDITIONAL REQUIREMENTS

a) Ultrasonic inspection of the ends, and at least 35% of the surface of the plate/coil or pipe to identify imperfections that impair serviceability such as laminations, cracks and inclusions in accordance with ASTM A578/A578M Level B, or Clause 7.8.10 of the 43rd Edition of API 5L as shown currently in §192.112 of 49 CFR 192, or equivalent method, must be carried out on at least 95% of the lengths of pipe manufactured.

b) Centerline segregation shall be monitored by means of a macro etch test or equivalent method on the first or second slab of each casting sequence, and graded with an acceptance criteria of two or better on the Mannesmann scale, or equivalent. Sulphur prints are not an acceptable method for monitoring centerline segregation.

c) Hardness testing using Vickers (HV10), or equivalent test method, shall be conducted on a cross-section of the weld seam of one pipe from each heat plus one pipe from each welding line per day. Each cross-section shall have a minimum of 13 readings (three for each HAZ, three in the weld metal and two in each section of the pipe base metal). The maximum hardness shall be 280 Vickers (HV10), or equivalent.

d) For pipe to be used in a new pipeline segment installed after October 1, 2015, mill hydrostatic test must be conducted at a gauge pressure corresponding to a hoop stress of 95% SMYS without end load compensation.

e) The requirements for minimum full size CVN absorbed energy for the pipe body, weld seams and HAZ shall be specified by the Company in accordance with the requirements of §192.112 of 49 CFR 192 and any amendments or errata issued by the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration. The requirements for absorbed energy may be higher than those specified in Table 9-3 of this Specification.

PURPOSE

This Specification outlines the requirements for the materials, qualification, manufacture, testing and inspection of high frequency electric-welded steel line pipe.

SCOPE/APPLICABILITY

This Specification applies to high frequency electric-welded steel line pipe (as defined in Clause 4.19 and 4.23 of API 5L) purchased for use in the Company's non-sour natural gas and liquid hydrocarbon onshore pipeline systems in Canada, the United States (U.S.) and Mexico.

This Specification applies to pipe with a specified outside diameter (OD) of 273.1 mm O.D. (NPS 10) to 660 mm O.D. (NPS 26). The pipe grade shall not exceed L485M (X70M).

This Specification is to be used in conjunction with the American Petroleum Institute (API) 5L *Specification for Line Pipe*, latest revision. This Specification covers requirements in addition to those of API 5L and any amendment, supplement or errata issued by API. All pipe shall meet, as a minimum, the requirements of API 5L.

The headings and numbering in this Specification correspond to those in API 5L. Where no incremental requirements are given in this Specification, API 5L shall apply as written. If conflict exists between this Specification and the requirements in API 5L, the more stringent of the requirements shall apply.

The Responsible Engineer shall be contacted for clarification if needed.

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GLOSSARY

ASME

American Society of Mechanical Engineers

ASTM

American Society for Testing and Material

CFR

Code of Federal Regulations

Company or Purchaser

TransCanada PipeLines Limited, its corporate affiliate or its agent.

CSA

Canadian Standards Association

DOT

United States Department of Transportation

High frequency electric welded pipe

Electric welded pipe produced with a welding current frequency greater than or equal to 70 kHz.

ISO

International Organization for Standardization

Manufacturer or Vendor

Those parties that have been contracted by the Company to provide the specified items and includes their manufacturing facilities and sub-vendors.

MSS

Manufacturer Standardization Society

NEB

National Energy Board

NOM

Norma Oficial Mexicana

Purchase order

The purchasing document used to purchase the specified item(s).

Regulatory Authority

The national and/or local regulator having jurisdiction over the facility.

Rolling practice

The rolling parameters, which are within the essential parameters stated, are applied to a steel of specific alloy design to produce a steel having a desired set of physical properties.

Steelmaking practice

The specified chemical composition (including specified tolerances), refining and casting process used in making a heat of solid steel.

Technical Agreement

The document signed by the Company and the Manufacturer that states an agreement on a technical matter.

Welding Procedure

The Welding Procedure Specification, Procedure Qualification Record and all associated non-destructive and destructive test data.

WIC

Welding Institute of Canada

1 SCOPE

1.1 Purpose and Coverage

1.1.1 The requirements of the Annex documents referenced in this Specification, and the applicable Annex documents referenced in API 5L including Addendum documents thereto, shall be met as applicable. When specified, the pipe shall also be certified to meet CSA Z245.1, latest revision.

Pipe shall be supplied to meet the additional requirements outlined on the purchase order documentation or requests for proposal, whichever is applicable.

6 PIPE GRADE, STEEL GRADE, AND DELIVERY CONDITION

6.2 Delivery Condition

6.2.3 All pipe shall, as a minimum, meet the product specification level PSL 2 requirements in regard to API 5L, and Category II in regard to CSA Z245.1, if specified.

6.3 Right of Rejection

6.3.1 Where less than 50% of the pipe length formed from any heat, rolling practice, coil or lot complies with all other requirements of this Specification, the Company reserves the right to reject all pipe from the affected heat, rolling practice, coil, slit or lot. The Manufacturer is responsible for obtaining the Company's written authorization prior to the acceptance of any pipe from such heats, rolling practice, coils, slits or lots.

Note:

Right of rejection shall apply to issues associated with the manufacturing process.

6.4 Welder Qualifications

6.4.1 Pipe supplied for welder qualifications shall be of the highest carbon equivalent of the order.

8 MANUFACTURING

8.3 Starting Material

8.3.2.1 The steel used for the manufacture of pipe shall be micro-alloyed, fine grain, fully killed, continuously cast steel with inclusion shape control. The steelmaking practice shall be identified with a steelmaking practice number.

8.3.2.2 The rolling practice shall be identified with a rolling practice number.

8.3.2.3 All skelp shall be inspected for laminar-type imperfections by a procedure submitted to and accepted by the Company in writing prior to the commencement of production. It shall be permissible to perform the inspection on rolled pipe.

8.3.2.3.1 Any lamination in the body of the pipe or coil shall be considered a defect if its non-destructively determined dimensions exceed both of the following:

a) ≥ 20 mm (0.79 in.) in the circumferential direction; and

b) an area of 7000 mm^2 (10.85 $in.^2$)

8.3.2.4 For all casting methods, the Manufacturer shall have a written method of monitoring the severity of centerline segregation present in either the slab or skelp to minimize the extent of segregation. This method shall be made available to the Company on request. The centerline segregation acceptance level shall be presented as part of the bid documentation.

8.11 Jointers

8.11.1 Supply of jointers shall not be permitted.

8.13 Traceability

8.13.2.1 The Quality Assurance program in effect shall provide documentation that allows traceability of the skelp rolling practices and heat, slab and coil used for each pipe section. If this documentation cannot be supplied, the Company will treat each coil produced during a particular mill work shift as being from a different heat, and the frequency of testing shall be increased accordingly.

8.14 Manufacturing Procedure Specification

8.14.1 As part of the quotation for the supply of line pipe under this Specification, the Manufacturer shall submit a Manufacturing Procedure Specification (MPS) document providing the information including, but not limited to, that listed in B.3.1 of Annex B of this Specification. The MPS shall be approved by the Company in writing prior to the commencement of production. Any subsequent changes to the approved MPS shall be approved by the Company in writing prior to implementation.

8.14.2 In addition to the MPS, the Manufacturer shall submit a document that clearly cross-references the locations in the MPS where the requirements outlined in B.3.1 of Annex B and in Clause E.5.8 of this Specification can be found.

9 ACCEPTANCE CRITERIA

9.2 Chemical Composition

9.2.2 Heat analysis and product analysis shall conform to the chemical composition limits specified in Table 9-1 of this Specification. The weight percent for all elements included in Table 9-1 shall be reported, and shall be provided to the same number of decimal points as shown in Table 9-1.

Table 9-1: Chemical Composition Limits

Element	Symbol	Maximum % (unless range is specified)
Carbon	C	0.10, See Restriction A

Element	Symbol	Maximum % (unless range is specified)
Manganese	Mn	1.55 for L245M to L320M, see Restriction A 1.65 for L360M & L390M, see Restriction A 1.75 for L415M & L450M, see Restriction A 1.90 for L485M, see Restriction A
Phosphorus	P	0.020
Sulphur	S	0.010
Silicon	Si	0.40
Niobium (Columbium)	Nb (Cb)	0.100 for L360M to L485M, see Restrictions B & C
Vanadium	V	0.090 for L360M to L485M, see Restrictions B & C
Titanium	Ti	0.004 - 0.030 for L360M to L485M, see Restriction C
Aluminum	Al	0.010 min, 0.060 max (ASA†)
Aluminum	Al	0.020 min, 0.120 max (total†)
Nitrogen	N	0.014
Copper	Cu	0.40
Chromium	Cr	0.30, see Restriction A
Molybdenum	Mo	0.30, see Restriction A
Nickel	Ni	1.00
Calcium	Ca	0.0050
Cerium	Ce*	No deliberate additions
Boron	B	0.0010, no deliberate additions
Carbon Equivalent **	CE (*Pcm*)	0.200

Notes:

* For facilities that have no deliberate additions of Cerium, it is not necessary to report.

** The carbon equivalent shall be calculated in accordance with the requirements of Clause 9.2.4 of API 5L.

† Either the acid soluble aluminum (ASA) or total aluminum content shall be reported. It is not necessary to determine and report both values.

Restrictions:

Restriction A: See Table 9-2

Restriction B: V + Nb : 0.12 max for L360M to L485M

Restriction C: V + Nb + Ti : 0.15 max for L360M to L485M

Table 9-2: Restriction A

Carbon Content	Mn Max for L245M to L320M (BM to X46M)	Mn Max for L360M & L390M (X52M & X56M)	Mn Max for L415M & L450M (X60M & X65M)	Mn Max for L485M (X70M)	(Mn+Cr+Mo) Max for L245M to L390M (BM to X56M)	(Mn+Cr+Mo) Max for L415M to L485M (X60M to X70M)
≥ 0.09	1.30	1.40	1.50	1.60	1.85	1.95
0.08	1.35	1.45	1.55	1.65	1.90	2.00
0.07	1.40	1.50	1.60	1.70	1.95	2.02
0.06	1.45	1.55	1.65	1.75	2.00	2.07
0.05	1.50	1.60	1.70	1.85	2.05	2.20
≤ 0.04	1.55	1.65	1.75	1.90	2.10	2.25

Note:
Carbon values intermediate to those listed (i.e., C=0.085) shall be rounded in accordance to ASTM E29.

9.3 Tensile Properties

9.3.2.1 The ratio of yield strength to tensile strength (Y/T) for transverse body tensile tests, Table 7 of API 5L, shall not exceed 0.90.

9.3.2.2 The ultimate tensile strength maximum limit for the pipe body shall also apply to the weld.

9.6 Flattening Test

a) 1) For all combinations of pipe grade and specified wall thickness, there shall be no opening of the weld before the distance between the plates is less than 50% of the original outside diameter.

9.8 CVN Impact Test for PSL 2 Pipe

9.8.2 Pipe Body Tests

9.8.2.1 Pipe body tests shall meet the requirements outlined in Table 9-3 of this Specification, based upon full-size test specimens, at or lower than the pipe test temperature specified on the purchase order.

9.8.2.2 For all pipe sizes, the fracture appearance as determined by a Charpy V-notch impact test shall exhibit a fracture appearance shear area of 85% minimum for any test, with no individual test specimen exhibiting less than 75% shear area, at the test temperature outlined in the purchase order.

9.8.3 Pipe Weld and HAZ Tests

Charpy V-notch impact tests shall be conducted on test specimens taken from the weld zone. Shear area shall be reported for information only, unless otherwise specified or agreed.

Table 9-3: CVN Absorbed Energy Requirements for Pipe Body

Overall Design Factor[1]	Pipe Size in mm O.D. (NPS)	Minimum Full Size Charpy V-Notch Absorbed Energy J (ft. lbs)[6]		
		Pipe Body[2]		Weld Zone
		Any Heat[2]	All Heat Average[2,3]	Longitudinal Weld[4]
> 0.60	610 (24)	45 (33)	100 (74)	45 (33)
> 0.60	457-559 (18-22)	40 (30)	80 (59)	40 (30)
> 0.60	≤ 406.4 (16)	27 (20)	55 (41)	27 (20)
≤ 0.60	≥ 457 (18)	40 (30)	55 (41)	40 (30)
≤ 0.60	≤ 406.4 (16)	27 (20)	40 (30)	27 (20)
N/A[5]	≥ 457 (18)	40 (30)	55 (41)	40 (30)
N/A[5]	≤ 406.4 (16)	27 (20)	40 (30)	27 (20)

Notes:

[1] The overall design factor will be specified on the purchase order and the request for quote. In Canada, the overall design factor equals the design factor multiplied by the location factor.

[2] Pipe Body "Any Heat" and "All Heat Average" values are based on specific design conditions, including a maximum design pressure of 10,000 kPa (1450 psi). If the design pressure exceeds 10,000 kPa (1450 psi), the values shall be re-assessed by the Company and higher values may be specified. Higher values may also be specified for special design conditions (e.g., rich gas or lower design temperatures).

[3] The "All Heat Average" requirement is recommended, but is not mandatory, for pipe ordered for liquid hydrocarbon pipeline systems, and does not apply to pipe for orders filled by the production of less than five heats.

[4] Shear area of the weld zone shall be reported for information.

[5] N/A = Not Applicable

[6] The values in ft. lbs are converted from the values in J.

9.9 DWT Test for PSL 2 Welded Pipe

9.9.1.1 For pipe larger than 457 mm O.D. (NPS 18), the fracture appearance as determined by a drop-weight tear test shall exhibit a shear area of 85% minimum for any test, with no individual test specimen exhibiting less than 75% shear area, at or lower than the test temperature outlined on the purchase order.

9.10 Surface Conditions, Imperfections and Defects

9.10.4 Laminations

Laminations of any size extending into the face or bevel of the pipe shall be classified as defects. Pipes that contain such defects shall be rejected or cut back until no such lamination is present at the pipe ends.

9.10.5 Geometric Deviations

9.10.5.1 Geometric deviations, other than dents, from the normal cylindrical contour of the pipe (e.g., flat spots and peaks) that exceed 2.0 mm (0.08 in.) in depth or height shall be considered defects and treated in accordance with C.3 b) or C.3 c) of API 5L.

9.10.5.2.1 Dents that are 6.4 mm (0.25 in.) or less in depth and contain stress concentrators shall be considered defects and shall be cut out as cylinders and rejected, or shall be repaired by grinding to remove stress concentrators provided that the remaining wall thickness is within the specified limits.

9.10.5.2.2 Dents of any depth that intersect the longitudinal weld seam shall be considered defects and removed from the pipe as a cylinder.

9.10.6 Hard Spots

Any hard spot larger than 50 mm (2.0 in.) in any direction shall be classified as a defect if its hardness exceeds 300 HV10, based upon individual indentations.

9.10.7 Other Surface Imperfections

Other surface imperfections found by visual inspection shall be investigated, classified and treated in accordance with Clause 9.10.7 of API 5L and as follows:

a) Surface scores (sharp notches, gouges, scores, slivers, pits, etc.) and all other stress raising imperfections shall be removed by grinding even though they may be less than the maximum depth permissible for imperfections.

c) Any OD or ID imperfection having a depth that results in a remaining wall thickness at any point of less than 95% of the specified nominal wall thickness shall be considered a defect.

d) The external pipe surface shall be suitable for coating with fusion bond epoxy and polyethylene. Pipe shall have an internal surface suitable for coating with liquid epoxy. Slivers, scabs, bristles or other surface imperfections that would result in an unacceptable applied internal or external coating shall be considered defects and shall be removed by grinding.

9.10.7.1 Grinding

9.10.7.1.1 The minimum remaining wall thickness at any point after grinding shall not be less than 95% of the nominal ordered thickness.

9.11 Dimensions, Mass and Tolerances

9.11.3 Tolerances for Diameter, Wall Thickness, Length and Straightness

9.11.3.1.1 Diameter

9.11.3.1.1.1 Tolerances for diameter of the pipe, except the ends, and for diameter of the pipe ends shall be in accordance with requirements of Table 10 of API 5L, except that the diameter tolerances shall not exceed plus or minus 2.0 mm (0.08 in.) at any location along the length of the pipe.

Unless otherwise agreed, the diameter of each pipe joint shall be measured at each end (within 100 mm or 4 in.) plus three equally spaced intervals along the pipe body after hydrostatic test.

9.11.3.1.1.2 For pipe larger than 457 mm O.D. (NPS 18), the tolerances on outside diameter at the ends may be applied instead to the inside diameter at the ends.

9.11.3.1.2 Out-of-Roundness

9.11.3.1.2.1 For all pipe sizes and D/t ratios, the maximum difference between the lengths of the major and minor axes at any point along the pipe shall be in accordance with the out-of-roundness requirements of Table 10 of API 5L, with the additional requirement that in no case shall the maximum difference between the lengths of the major and minor axes at any point exceed 0.010 D.

9.11.3.2 Wall Thickness

9.11.3.2.1 The minimum wall thickness at any location shall be 95% of the specified wall thickness.

9.11.3.2.2 The average wall thickness for the quantity on the purchase order when five or more heats are provided shall not be less than the specified wall thickness. It shall be permissible to establish compliance with this requirement on the basis of mass.

9.11.3.3 Length Tolerances

a) The minimum length, minimum average length and maximum length shall be identified on the quotation by the Manufacturer and shall be subject to prior agreement by the Company.

9.11.3.4 Straightness Tolerance

b) The local deviation from a straight line in the 1,000 mm (39 in.) portion at each pipe end shall be less than or equal to 2 mm (0.08 in.).

9.12 Finish of Pipe Ends

9.12.5 Plain Ends

9.12.5.2.1 Pipe shall be furnished with a root face dimension of 1.6 mm (0.063 in.), +0.8 mm (0.031 in.), -0.0 mm (-0.0 in.) for a minimum of 95% of the circumference around each field end.

9.12.5.2.2 For station pipe orders, pipe shall be furnished with a root face dimension as per the requirements of API 5L.

9.13 Tolerances for the Weld Seam

9.13.1 Radial Offset of Strip/Plate Edges

9.13.1.1 The maximum offset for all wall thicknesses and at any location in the pipe shall be 10% of the specified wall thickness.

9.15 Weldability of PSL 2 Pipe

9.15.1 Weldability tests shall be conducted in accordance with and shall meet the requirements of the *WIC-1 Testing Procedure Specification* in Annex Q of this Specification. Weldability tests are required when the pipe is Grade L415M (X60M) or higher. Weldability tests shall not be required for station pipe orders.

9.15.2 Weldability tests shall be repeated when any of the following conditions occur:

a) the carbon equivalent, calculated in accordance with the requirements of Clause 9.2.4 of API 5L, increases by more than 0.03 from the previously accepted test result

b) the specified wall thickness increases more than 10% within one of the ranges specified in the following note:

Note:

There are two wall thickness ranges:

i. < 7.3 mm (0.288 in.), and

ii. ≥ 7.3 mm (0.288 in.)

c) the grade increases from the previously accepted test results

d) the steelmaking practice changes

e) the steel Manufacturer or the location of the steelmaking facility changes

f) when a new heat is provided, until a total of three heats have been tested and have been found to meet the requirements of Annex Q of this Specification

9.15.3 Provided that the requirements of Clause 9.15.2 of this Specification are met, successful WIC tests submitted as part of a previous order may be used to satisfy the requirements of a current order.

9.15.4 If more than one of the three test welds in a heat fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected. If one of the three test welds on any heat fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected or two additional test welds from the same heat shall be taken. If either of the two additional test welds fails to meet the requirements specified in Annex Q of this Specification, the heat shall be rejected.

9.15.5 When a heat is rejected, two additional heats of steel shall be tested. If either of these additional heats is rejected, the acceptance of every heat of steel for the order shall be subject to agreement by the Company.

10 INSPECTION

10.1 Types of Inspection and Inspection Documents

10.1.3 Inspection Documents for PSL 2 Pipe

10.1.3.1 Pipe shall not be considered for acceptance until two copies of the reports and test certificates required by Clause 10.1.3 of this Specification are provided. The reports and test certificates shall be in a format approved by the Company.

10.1.3.2 In addition to the information to be provided in accordance with Clause 10.1.3.2 of API 5L, the following additional information shall be provided:

b) Chemical composition (heat and product) and acceptance criteria for all elements referenced in Table 9-1 of this Specification and all alloying elements intentionally added, carbon equivalent (heat analysis and product analysis) and acceptance criteria. Additionally, the values of all restrictions listed in Table 9-1 of this Specification shall be reported.

c) Mechanical test results, including results for body tensile tests (including Y/T ratio), transverse weld tensile tests, flattening tests, guided-bend tests, notch toughness tests and macrohardness tests, and heat number and qualification pipe number for each test. For flattening and guided-bend tests, it shall be permissible to supply certification that the tests were completed.

d) CVN impact test results, the size, orientation and location of the test pieces; the source (pipe body or weld), type (flattened or unflattened), individual and average test results for each test, type of testing machine (ISO or ASTM), heat number and qualification pipe number for each test, and acceptance criteria for each CVN test.

e) DWT test results, type of specimen (flattened or unflattened), type of notch (pressed or chevron), type of testing machine (ISO, ASTM or API), individual and average test results for each test, heat number and qualification pipe number for each test and acceptance criteria for each DWT test.

m) The results of weld zone metallographic examinations (it shall be permissible to supply a certificate that the tests were done in accordance with, and met the requirements of, this Specification in lieu of actual test results).

n) The results of all hardness tests.

o) Steelmaking method, steelmaking practice number, deoxidation practice and casting method.

p) Rolling practice number and the type of skelp rolling mill used.

q) Purchase order number.

r) Certification that non-destructive inspection was performed in accordance with, and met the requirements of Clause 10.2.10 of this Specification and API 5L.

s) A correlation of heat numbers to pipe numbers (for sequential pipe numbers), or heat numbers to pipe and coil numbers.

t) Certification that the pipe has been manufactured in accordance with the requirements of API 5L and this Specification, and/or dual certification to CSA Z245.1, if specified.

10.2 Specific Inspection

10.2.1 Inspection Frequency

10.2.1.2 The inspection frequency shall be as given in Table 18 of API 5L, and as outlined in this Specification.

4 & 6: The minimum inspection frequency for tensile testing, as per Table 18 of API 5L, shall be once per test unit of not more than 100 lengths of pipe for pipe sizes covered under this Specification.

9, 10, 11 &12: The minimum inspection frequency for CVN pipe body, weld and HAZ, Table 18 of API 5L, shall be once per test unit of not more than 100 lengths of pipe.

13: The minimum inspection frequency for DWT test for welded pipe, as per Table 18 of API 5L, shall be once per test unit of not more than 100 lengths of pipe.

14 & 15: One root guided-bend test shall be conducted for each of the leading end of the first pipe and the trailing end of the last pipe of each multiple length. For each individual slit/coil of skelp welded, a multiple length is defined to be the tubular product that is bounded by the following:

a) for slits/coils welded without an intermediate weld stop, the leading and trailing slit/coil end locations, or

b) for slits/coils welded with one or more intermediate weld stops:

i. the leading slit/coil end location and the first subsequent weld stop location

ii. any two consecutive intermediate weld stop locations, and

iii. the last intermediate weld stop location and trailing slit/coil end location

20: At least once per operating shift, and at least once for each heat of material supplied to an order, at least one metallographic examination shall be conducted on the weld area to confirm that the full weld has been heat-treated in accordance with Clause 8.8.2 of API 5L. Metallographic examination shall be conducted for all pipe orders.

10.2.3 Samples and Test Pieces for Mechanical Tests

10.2.3.1.1 Samples and test pieces for mechanical tests (tensile tests, CVN tests and DWT tests) shall be taken from the same end of the same length of pipe that is sampled for testing.

10.2.3.2 Test Pieces for Tensile Test

10.2.3.2.1 The use of round test specimens shall be subject to agreement by the Company.

10.2.3.3 Test Pieces for the CVN Impact Test

10.2.3.3.1 Test specimens for weld zone tests shall be etched prior to notching to enable proper placement of the notches. Test specimens shall be oriented transversely to the longitudinal axis of the pipe and the notches shall be located in the heat-treated area. The axis of the notch shall be located on, or as close as practicable to the weld line. Test specimens shall be full size, or the largest obtainable sub-size commensurate with the pipe geometry. The tests shall meet the requirements outlined in Table 9-3 of this Specification, at the pipe test temperature outlined on the purchase order.

10.2.4.6 **Guided-Bend Test**

10.2.4.6.1 All pipe shall be subjected to the root guided-bend test and follow Clause 10.2.4.6 of API 5L using specimens prepared in accordance with Figure 8 b) of API 5L. Specimens shall be the full wall thickness of the pipe.

10.2.4.8 **Hardness Test**

10.2.4.8.1 The results of all hardness tests shall be reported.

10.2.4.8.2 Macrohardness traverses shall be taken on a representative sample at least once per welding shift and at least once for each heat of material supplied to an order. Tests shall be conducted in accordance with the requirements of one of the following:

a) ASTM E18 and the Rockwell A, B, or C scale

b) ASTM E384, with Vickers 10 kg force load

Note:

Once a scale is selected, it shall be used for the entire order.

10.2.4.8.3 For pipe with a specified wall thickness of 5.6 mm (0.219 in.) or less, one hardness traverse along the wall thickness centerline shall be taken. For pipe with a specified wall thickness greater than 5.6 mm (0.219 in.), two hardness traverses, with one traverse near the inside surface (1-2 mm (0.040-0.080 in.)) and one traverse near the outside surface (1-2 mm (0.040-0.080 in.)) shall be taken, as shown below. Each traverse shall consist of the following:

a) one reading taken within the weld

b) one reading on each side of the weld in the heat-affected zone, and

c) one reading on each side of the weld in the parent metal

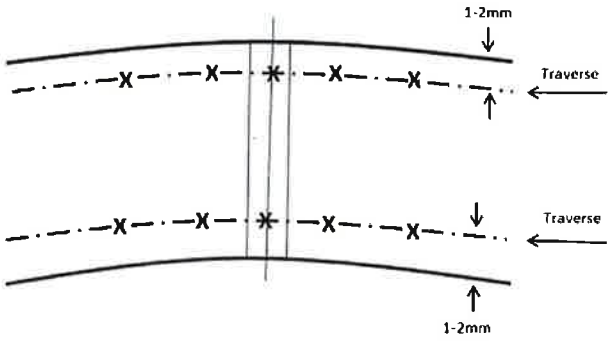


Figure 10-1: Hardness Traverse

10.2.4.8.4 Macrohardness shall not exceed 24 HRC or an equivalent value obtained by conversion from another macrohardness scale in accordance with the requirements of ASTM E140.

10.2.4.8.5 In the event of a hardness test failure, a documented proposal for the location and number of retests shall be prepared by the Manufacturer and submitted for approval by the Company.

10.2.5 Macrographic and Metallographic Tests

10.2.5.5 Weld Zone Microstructure

10.2.5.5.1 The results of all weld zone metallographic examinations shall be reported. The presence of untampered martensite shall not be allowed.

10.2.6 Hydrostatic Test

10.2.6.1 The test pressure for all pipe sizes shall be held constant for a duration of not less than 10 seconds.

10.2.6.2.1 The individual pressure recordings shall be unambiguously traceable to each pipe number and heat number.

10.2.6.2.2 Hydrostatic gauges are to be calibrated prior to commencement of production of pipe of each diameter, wall thickness and grade, at least weekly thereafter, and after all hydrostatic test failures.

10.2.6.5 The pressure of the hydrostatic test medium shall stress the pipe wall to at least 95% of the specified minimum yield strength (SMYS).

10.2.6.6 Any proposals to determine test pressure by applying end load compensation in accordance with Equation (7) of API 5L shall be indicated at the time of submission of proposals for supply. The hoop stress induced by the hydrostatic pressure as calculated by Equation (6) of API 5L (i.e., without end load compensation) shall be at least 90% SMYS.

10.2.6.7 The required test pressure shall be determined using the specified nominal wall thickness, *t*.

10.2.6.8 Reporting of Hydrostatic Test Failure

10.2.6.8.1 Each hydrostatic test failure shall be investigated and the cause of each failure determined and fully documented. The failure investigation results shall be forwarded to the Company.

10.2.7 Visual Inspection

10.2.7.1.1 The external and internal surfaces of the pipe shall be presented for final visual inspection free of oil, grease, lubricant, loose mill scale or other foreign matter.

10.2.7.1.2 All pipe shall be visually inspected. Visual inspection shall include, but not be limited to, the following:

c) the entire external surface by an inspector walking the full length of the pipe

d) the internal surface by an inspector using suitable inspection lamps

e) the pipe ends

10.2.10 Non-Destructive Inspection

10.2.10.1 All non-destructive final inspection procedures shall be submitted and accepted by the Company prior to pipe production. Non-destructive inspection shall be in accordance with Annex E of API 5L and this Specification.

10.2.12 Retesting

10.2.12.5 Guided-Bend Retests

Where one or both of the root guided-bend tests representing a multiple length fail to conform to the specified requirements, the affected multiple lengths shall be given one of the following dispositions:

a) The pipes produced from the affected multiple lengths shall be rejected.

b) The Manufacturer may elect to repeat the tests on specimens cut from two additional lengths of consecutive pipes adjacent to the defective portion from the affected multiple length. If such specimens conform to

the specified requirements, all lengths in the affected multiple length shall be accepted, except the length initially selected for test. If any of the retested specimens fail to pass the specified requirements, the Manufacturer may elect to test specimens cut from individual lengths remaining in the affected multiple length. The Manufacturer may also elect to retest any length that has failed to pass the test by cropping back and cutting two additional specimens from the same end. If the requirements of the original test are met by both of these additional tests, that length shall be acceptable. No further cropping and retesting is permitted. Specimens for retest shall be taken in the same manner as the original specimen that failed to meet the requirements.

10.2.12.6 Charpy Retests

10.2.12.6.1 For CVN impact tests on pipe weld areas, failure of any test shall require two additional tests; one on the pipe immediately before the failed pipe and the second on the pipe immediately after the failed pipe. If both retests conform to the requirements, the pipe in the lot shall be accepted, except that pipe from which the initial test was taken. If one or both tests fail to meet the requirements, the Manufacturer shall take additional tests, one on the pipe welded immediately before the last retest failure, and the second on the pipe immediately after the last retest failure, until the respective tests pass the requirements. All pipe welded after the acceptable retest preceding the original failure, and all pipe welded prior to the acceptable retest after the original failure shall be rejected.

11 MARKING

11.2 Pipe Markings

11.2.1 The markings shall also include the pipe number and coil number as applicable, heat number (or code traceable to the heat number) and purchase order number.

Note:

The coil number is not required for mills that use sequential pipe numbers in lieu of coil and pipe numbers, provided that the coil number can be determined from the sequential pipe number.

11.2.3 Die-stamping and/or vibro-etching shall not be permitted on any pipe surface.

11.2.4 If agreed, the pipe markings as required on the OD of the pipe may be applied after subsequent coating application. In such case, the pipe markings on the ID of the pipe, as required per this Specification and approved for the project, shall be completed before coating application and traceability shall be ensured.

11.2.8 Additional markings applied shall be at the approval of the Company.

11.2.9 All markings required by API 5L, the purchase order number, heat number (or code traceable to the heat number), and pipe number shall be marked on the inside and/or outside surface of the pipe in accordance with Table 11-1.

Table 11-1: Location of Markings

Pipe Size in mm O.D. (NPS)	API Marking and Heat Code	Pipe / Coil Number	PO Number
≤ 355.6 (14)	OD	ID and OD	ID and OD
> 355.6 (14)	ID	ID and OD	ID and OD

The heat code, purchase order number, pipe number and, where required by Clause 11.2.1 of this Specification, the coil number shall be placed at both ends of each length of pipe.

Figure 11-1 and Table 11-2 provide further detail on where markings should be placed.

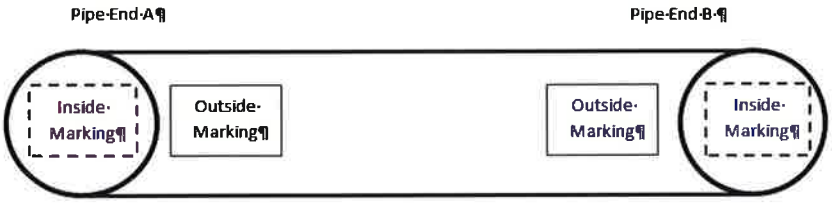


Figure 11-1: Location of Pipe Markings

Table 11-2: Specific Location of Pipe Markings

Pipe Size in mm O.D. (NPS)	Pipe End A		Pipe End B	
	Outside Marking	Inside Marking	Outside Marking	Inside Marking
≤ 355.6 (14)	1. API 5L Clause 11 requirements 2. Pipe Number 3. PO Number	1. Pipe Number 2. PO Number	1. Pipe Number 2. PO Number	1. Heat Code 2. Pipe Number 3. PO Number
> 355.6 (14)	1. Pipe Number 2. PO Number	1. API 5L Clause 11 requirements 2. Pipe Number 3. PO Number		

12 COATINGS AND THREAD PROTECTORS

12.1 Coatings and Linings

12.1.1 Unless otherwise stated on the purchase order, pipe shall be supplied with bare metal finish.

15 ADDITIONAL DOCUMENTATION REQUIREMENTS

15.1 Documentation Requirements

15.1.1 The Manufacturer shall submit the following documents to the Company within the time period shown:

a) Weldability test results no later than the cargo shipment readiness date (see Clause 9.15 of this Specification).

b) Number of metres shipped and number of pipe lengths shipped within five working days after each shipment.

c) For orders of 10 heats or more, product histograms for each of the items listed in Table 15-1 shall be supplied within one month after the completion of production. The minimum, maximum, arithmetic mean (average), median value, number of samples and standard deviation shall be reported clearly either in the histograms or separately. For items 1 to 15 in Table 15-1, histograms shall be prepared for both the heat analysis and product analysis.

Table 15-1: Items Requiring Product Histogram Documentation

1. Carbon Equivalent	13. Titanium
2. Carbon	14. Aluminum
3. Manganese	15. Nitrogen
4. Silicon	16. Transverse Yield strength
5. Sulfur	17. Transverse Tensile strength
6. Phosphorus	18. Transverse Weld Tensile Strength
7. Copper	19. Yield/Tensile ratio (Y/T)
8. Nickel	20. CVN Absorbed Energy - pipe body
9. Chromium	21. CVN Shear Area - pipe body
10. Molybdenum	22. DWTT Shear Area - pipe body
11. Vanadium	23. CVN Absorbed Energy – weld
12. Niobium (Columbian)	24. CVN Shear Area – weld

d) In addition to the reports and test certificates supplied with the pipe shipments, the final certification documents shall be submitted within two weeks of completion of production. Two paper copies and one non-modifiable searchable electronic copy are required.

15.2 Pre-Production Documentation Requirements

15.2.1 The Manufacturer shall supply the Company, at the time of quotation, any exceptions or alternatives to this Specification. The minimum length, minimum average length and maximum length shall be identified at the time of quotation. In addition, the centerline segregation acceptance level shall be presented.

15.2.2 The Manufacturer shall supply the Company, at the time of quotation, a Manufacturing Procedure Specification (MPS) (see Clause 8.14 of this Specification).

15.2.3 Prior to the commencement of production, the Manufacturer shall submit or have previously submitted to the Company the following documents, and shall have received written acceptance of such from the Company:

a) Ultrasonic inspection procedures for the skelp or pipe body (see Clause 8.3.2.3 of this Specification).

b) Ultrasonic inspection procedure for the weld (see Clause E.5.8 of this Specification).

c) If applicable, an alternative procedure for removing markings identifying imperfections (see Clause E.3.5.1 of this Specification).

d) Liquid penetrant, magnetic particle or ultrasonic inspection procedures, whichever are applicable, for the pipe ends (see Clause E.3.4.1 of this Specification).

e) Procedures for the welding of electric welded pipe. These procedures shall include production limits for such items as travel speed, welder electrical frequency, power input into weld and heat-treating temperature used in making the weld.

The Manufacturer shall inform the Company in writing of any changes to the above documents and shall obtain the written acceptance of the Company for such changes prior to implementing the changes.

15.2.4 The Manufacturer shall have written procedures for the loading, shipping and storage of pipe. These procedures are to be made available to the Company on request.

16 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are listed in Table 16-1, Table 16-2 and Table 16-3. Use the latest document revision, unless otherwise approved by TransCanada.

Table 16-1: Regulatory References

Organization/Document No.	Title
National Energy Board (NEB)	SOR/99-294, *National Energy Board Onshore Pipeline Regulations (NEB OPR)*
NOM-007-SECRE	*Transporte de Gas Natural*
U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) Code of Federal Regulations (CFR)	Title 49 Part 192, *Transportation of Natural Gas by Pipeline: Minimum Safety Standards*
	Title 49 Part 195, *Transportation of Hazardous Liquids by Pipeline*
Various	Other applicable federal, provincial and territorial safety acts and regulations by the authority having jurisdiction

Table 16-2: External Industry References

Organization/Document No.	Title
American Petroleum Institute (API)	5L, *Specification for Line Pipe*
American Society for Testing and Material (ASTM)	E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*
	E140, *Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness*
American Society of Mechanical Engineers (ASME)	B31.4, *Pipeline Transportation Systems for Liquids and Slurries*
	B31.8, *Gas Transmission and Distribution Piping Systems*
	BPVC-IX, *Welding and Brazing Qualifications*
Canadian Standards Association (CSA)	Z245.1, *Steel Pipe*
	Z662, *Oil and Gas Pipeline Systems*

Table 16-3: Internal References

Document No.	Title
For this Specification, there are no specific Internal references.	

17 DOCUMENT HISTORY

Rev.		
05	**Description**	**Effective Date**
	Revised document developed as part of Columbia Pipeline Integration.	2017-Aug-01
	Rationale Statement	**Responsible Engineer**
	This document was revised to address the following requirements: • Integration of Columbia Pipeline requirements.	Jessica de Vries, P. Eng.
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group, to integrate Columbia Pipeline requirements, and to make it more easily accessible to those who use it	Jessica de Vries, P. Eng.
04	**Description**	**Effective Date**
	Revised document developed as part of Engineering Standards Streamlining Process.	2016-Nov-01
	Rationale Statement	**Responsible Engineer**
	This document was revised in order to address the following requirements: • Alignment with new document definitions, structure, and templates.	Jessica de Vries, P. Eng
	Impact Assessment Summary	**Document Owner**
	This Specification was revised to streamline the documentation required for the Materials Engineering group and to make it accessible to those who use it.	Jessica de Vries, P. Eng

18 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
N/A	This Specification was updated and put into the new template. Changed name from TES-PIPE-EW to TES-MA-EWPI-GL following new naming convention.

19 APPROVALS

APPROVALS		
Originator: Derek Chen, P. Eng. Materials and Welding Engineering	Signature	Date: June 26, 2017
Reviewer: Cindy Guan, P. Eng. Materials and Welding Engineering	Signature	Date: June 26 2017
Reviewer: Jaclyn Brown, P.E. USGO Integrity Program Services	Signature	Date: 6/27/2017
Responsible Engineer: Jessica de Vries, P. Eng. Materials and Welding Engineering	Signature June 26, 2017 Date	APEGA Permit to Practice P7100
Management Endorsement: James Ferguson, P. Eng., Manager Materials and Welding Engineering	Signature	Date: June 26, 2017

ANNEX B MANUFACTURING PROCEDURE QUALIFICATION FOR PSL2 PIPE

B.3.1 Manufacturing Procedure Specification (MPS) Requirements

The Manufacturing Procedure Specification (MPS) submitted shall include, at a minimum, the following detailed information:

a) steel source, including steelmaking method, heat size, deoxidation practice, inclusion shape control practices and casting method

b) aim chemistries and chemical limits for all elements referenced in Clause 9.2 of this Specification, and as applicable to pipe of each diameter, wall thickness and material grade to be made for the order

c) skelp rolling source, specific rolling and forming practices, including where applicable, typical reduction schedules, final finishing temperatures, coiling temperatures or accelerated cooling stop temperature, and facilities for thermo-mechanical controlled rolling and on-line accelerated cooling

d) skelp inspection procedures as applicable

e) details of pipe forming procedures

f) pipe manufacturing location, and any plant limitations on wall thickness, diameter and material grade

g) welding method (induction or contact method), typical electrical parameters (voltage, amperage, and frequency) and production limits on travel speed, power input and post-weld heat treating temperature applicable to pipe for the order

h) a description of the quality organization applicable to steelmaking, casting, skelp rolling and pipe manufacturing facilities, including identification of reporting practices, verification mechanisms to assure product traceability in accordance with the requirements of API 5L, and responsibility for customer contact related to commercial and quality matters

i) a flow chart for pipe manufacturing, finishing and qualification processes

j) normal mill control tolerances, assessment and recording frequencies for all specification dimensions for pipe

k) laboratory test equipment present at the manufacturing plant for testing of material properties for the order

l) all non-destructive inspection procedures utilized for specification compliance and for production control, as applicable to skelp, pipe body and welds

m) method and typical amount of cold sizing/expansion, as applicable

n) yard handling, storage and shipping procedures, including drawings of proposed methods of stacking and securing pipe for shipment and method of end protection

o) order-specific Inspection and Test Plan (ITP) for Company review and approval

ANNEX E NON-DESTRUCTIVE INSPECTION FOR OTHER THAN SOUR SERVICE OR OFFSHORE SERVICE

E.1 Qualification of Personnel

E.1.1 ISO 9712 shall be the basis for the qualification of non-destructive inspection personnel (excluding visual inspection). Such personnel shall be re-qualified for any method previously qualified if they have not performed non-destructive inspection in that method for a period exceeding 12 months.

E.1.2 Non-destructive inspection shall be conducted by Level 2 or 3 personnel.

E.1.3 Evaluation of indications shall be performed by Level 2 or 3 personnel.

E.3 Methods of Inspection

E.3.1.3 The location of equipment in the Manufacturer's facility shall be such that all non-destructive inspection for compliance to specification requirements shall be performed after final hydrostatic testing.

E.3.4 Pipe End Bevel Inspection

E.3.4.1 The bevel area of all pipe shall be inspected for laminations by an ultrasonic inspection technique. Alternatively, the root face and bevel shall be inspected for laminations by a liquid penetrant or a magnetic particle technique after beveling. The inspection procedure shall be documented and accepted by the Company prior to production.

E.3.5 Removal of Markings

E.3.5.1 Any paint markings applied to the pipe to mark locations where alarm limits were exceeded or where imperfections were noted shall be removed or painted over with black paint, after it has been confirmed that a defect is not present. The Manufacturer may submit an alternative procedure for acceptance by the Company in writing if this requirement deviates from their standard practice.

E.5 Ultrasonic and Electromagnetic Inspection

E.5.1 Equipment

E.5.1.2 Search Units

E.5.1.2.1 The angle of the search units shall be selected to provide as near to perpendicular incidence of the soundbeam axis to the weld fusion line as is practical.

E.5.1.3 **Couplant**

E.5.1.3.1 An audio device shall be used to indicate the loss of coupling effectiveness.

E.5.2 Ultrasonic and electromagnetic inspection reference standards

E.5.2.3.1 Reference standards for standardization and inspection sensitivity checks shall contain machined standardization reflectors as follows:

a) 3.2 mm (0.125 in.) radially drilled hole for calibration and for application of acceptance limits and for setting of alarm levels.

b) For piping to be used in above ground assembly or station piping, a 1.0 mm (0.039 in.) radially drilled hole shall be used for calibration and for application of acceptance limits and for setting of alarm levels.

c) Notches, longitudinal orientation, depth 5% of specified wall thickness, dimensional tolerances as specified in Table E.7 of Annex E of API 5L, for the verification that the sound beam for longitudinal defect inspection is being directed perpendicular to the weld line.

E.5.3 Instrument standardization

E.5.3.1.1 Any signal suppression and electronic dampening implemented for standardization shall be identical to that implemented for inspection of the pipe during production.

E.5.3.1.2 Standardization shall be performed at the start of production, after the inspection sensitivity checks required by Clause E.5.4.1.1 of this Specification, and at the start of inspection after any shutdown of the ultrasonic inspection equipment during production. The inspection equipment shall be adjusted to obtain, from the applicable reference standards used to establish the acceptance limits, signals that are within the gate width and exceed the alarm limit, when the reference standard is scanned in a manner duplicating inspection in the dynamic mode.

E.5.3.1.3 The gate start locations and gate widths shall be validated during calibration by positioning the search units at locations coincident with the extremes of the tracking error, and producing signal amplitude at or above the alarm limit signal produced from the standardization reflector.

E.5.4 Records verifying system capability

E.5.4.1.1 The inspection sensitivity shall be checked at least twice every working shift, prior to any planned shutdown of the ultrasonic equipment during production, and at the end of production, using the reference standard containing the machined calibration reflectors specified in Clause E.5.2.3.1 of this Specification. For inspection sensitivity checks, the reference standard shall be run through the ultrasonic equipment at production speed.

E.5.4.1.2 Where the signal obtained from the standardization reflector is more than 3dB lower than the acceptance limit, all pipe inspected after the preceding acceptable standardization shall be re-inspected after re-standardization has been accomplished.

E.5.5 Acceptance Limits

E5.5.1.1 For inspection of the pipe welds, any imperfection that produces a signal greater than the applicable acceptance limit signal for the applicable radially drilled hole or transverse notch shall be considered to be a defect, and shall be dispositioned in accordance with Clause C.4 of Annex C of API 5L.

E.5.8 Procedures

An ultrasonic procedure shall be submitted to the Company for review and written acceptance prior to the start of production. The procedure shall include, but not be limited to, the following information as applicable to both the production-speed inspection system, and to any system used for manual prove-up of noted imperfections:

a) ultrasonic instrument equipment manufacturer(s) and model number(s)

b) industry recognized standard for verification of linearity as performed on instrumentation

c) a drawing clearly outlining the number of ultrasonic transducers in the system, and the location and position of all of the transducers

d) a drawing clearly outlining the identified area of inspection for each transducer, which clearly shows the gate width setting for each transducer or transducer set for dynamic mode inspection

e) a drawing or statement clearly outlining the maximum tracking error

f) a drawing clearly outlining the design of the reference standard, with details of the location and orientation of holes and surface notches used for standardization

g) the alarm limit settings applied for each of the applicable transducers or transducer sets

h) the mode of operation of each transducer or pair of transducers (pulse echo, transmit only, or receive only)

i) coupling medium utilized for the system

j) coupling alarm method

k) the shape and dimensions of each transducer

l) nominal search unit frequency for each transducer

m) sound entrance angle for each transmitting transducer

n) pulse repetition rate for each transducer or transducer set

o) maximum production-speed of pipe through the system

p) the marking device utilized and if applicable, the marking method and location of marking on the pipe as related to imperfection location

q) standardization procedure, including frequency for standardizations

r) sensitivity check procedure, including frequency for sensitivity checks

E.7.6 Four readings shall be taken approximately 90° apart around the circumference of each end of the pipe. The average of the four readings shall be ≤ 2.5 mT (25 Gauss), and no one reading shall exceed 3.0 mT (30 Gauss) when measured with a Hall-effect gaussmeter or equivalent values when measured with another type of instrument.

ANNEX Q WIC – 1 – TESTING PROCEDURE SPECIFICATION

Q1.0 SCOPE

Q1.1 This Specification defines the procedures and acceptance criteria for the evaluation of the weldability of line pipe material using the modified WIC test. The modified WIC test is a single pass restrained groove weld produced with cellulosic electrodes and it is used to evaluate the material's susceptibility to hydrogen cracking.

Q1.2 This Specification is applicable to the qualification of carbon and low-alloy steel pipe material.

Q2.0 TESTING PROCEDURE

Q2.1 Test assemblies

The materials required to fabricate the test assembly shown in Figure Q-1 are listed in Table Q-1. Each assembly shall be fabricated as follows:

The stiffener plate shall be welded to the bottom of the backing plate to prevent joint rotation. The shims shall be located beneath the test sections (Figure Q-2) and the test sections shall be fillet welded to the backing bar with a root gap of 1.5 mm ± 0.5 mm (typical). The restraint fillet welds shall be made using a low hydrogen process and welding shall proceed outwards relative to the weld joint preparation, see Figure Q-3. A distance of 25 mm ± 0.5 mm, centered over the weld joint preparation, shall not be welded to the backing bar and this constitutes the restraint length. Run-on and run-off tabs shall be used to ensure uniform weld deposition within the test weld. The run-on and run-off tabs shall be tack-welded to the backing plate only.

Q2.2 Number of test welds and preheat

For each heat of steel, a minimum of three acceptable test welds shall be evaluated to determine the cracking percentage at the preheat temperature given in Table Q-2.

Q2.3 Welding technique

Q2.3.1 All welding shall be performed in the vertical down direction with the test assembly located vertically (ASME Section IX 3G position). Welding can be performed manually; however, extensive practice may be required to achieve uniform travel speeds.

Q2.3.2 Test assemblies shall be uniformly heated in an oven to a temperature slightly higher than the desired preheat temperature. The assembly shall be removed from the oven and the temperature at the bevels monitored using a contact thermocouple. Welding shall begin as the required preheat given in Table Q-2 is reached.

Q2.3.3 Welding shall be performed with the consumables given in Table Q-2.

Q2.3.4 Welding parameters shall be monitored using external instrumentation for all tests. The combination of welding parameters shall be such that the resulting heat input is within the range given in Table Q-2.

Q2.4 Acceptable test weld workmanship

Q2.4.1 WIC test welds shall have a profile that is typical of the cellulosic root bead used for pipeline welding (see Figure Q-4). The weld shall be free of significant geometric flaws, which includes the following workmanship discontinuities:

a) incomplete penetration of the root bead

b) incomplete fusion of the root bead

c) porosity and hollow bead

d) coupon misalignment (high-low)

e) weld metal centre line solidification cracks

Q2.4.2 The test weld will be sectioned in accordance with the requirements of Clause Q2.5. The minimum weld throat thickness for each section shall be as given in Table Q-2. Unless the section is free of cracks, variation in the WIC test weld throat thickness for each section shall not exceed twice the actual throat thickness (depth of weld h_w, Figure Q-4). Should any of the examined sections fail to meet the workmanship requirements, the entire weld shall be discarded and replaced with another WIC test weld that meets the workmanship requirements.

Q2.5 Measurement of total crack percentage

The test welds shall be allowed to cool to room temperature and removed from the backing bar 24 hours after welding. If complete cracking occurs through the test weld, the total cracking percentage is 100%. If complete cracking through the weld does not occur, the weld shall be sectioned and examined microscopically for cracking. The weld shall be sectioned at the 1/4, 1/2 and 3/4 positions as shown in Figure Q-4. Faces 1A, 2A, 2B and 3B shall be polished, etched and examined at a magnification of 100X. The depth of cracking, h_c, and the depth of the weld (actual throat thickness), h_w, shall be determined for each section and the total cracking percentage for each test weld reported as follows:

$$\frac{\sum h_c}{\sum h_w} \times 100$$

Q3.0 ACCEPTANCE CRITERIA

Q3.1 Total cracking percentage

No single test weld shall result in a total cracking percentage exceeding the value given in Table Q-2.

Q4.0 REPORTING

A final report shall be completed for each weldability evaluation. The report, to include all the test welds completed for the evaluation, shall contain the following information:

a) material description

b) diameter, wall thickness and grade of the pipe tested

c) heat number

d) steelmaking practice (as identified by a unique practice number), steel manufacturer, and location of steel mill

e) mill test chemistry

f) consumable brand name, consumable manufacturer's traceability number (heat number, batch number or both), and the electrode diameter

g) weld parameters (amps, volts, travel speed and heat input) and preheat

h) crack dimensions and bead dimensions

i) summary of test results

j) test personnel names

k) date and number of report

l) signed certification

Table Q-1: Test Assembly Material Dimensions

Quantity	Material	Dimensions			Comments
		Thickness, t (mm)	Width, w (mm)	Length, l (mm)	
2	Test sections, (material under evaluation)	Thickness to be tested	50±1	150±5	One end prepared with standard bevel of pipe specification and oriented such that the actual test weld is deposited perpendicular to the plate/coil rolling direction or to the longitudinal axis of the pipe.
1	Backing plate, mild steel	19 min.	75 min.	300 min.	
1	Stiffener plate, mild steel	19 min.	75 min.	300 min.	
2	Backing shims, steel	3 min.	50 + 1, -10	140 +1, -20	

Quantity	Material	Dimensions			Comments
		Thickness, t (mm)	Width, w (mm)	Length, l (mm)	
2	Run on/off tabs, steel	3 min.	19±5	25 min.	Same thickness as backing shim.

Table Q-2: Testing Requirements

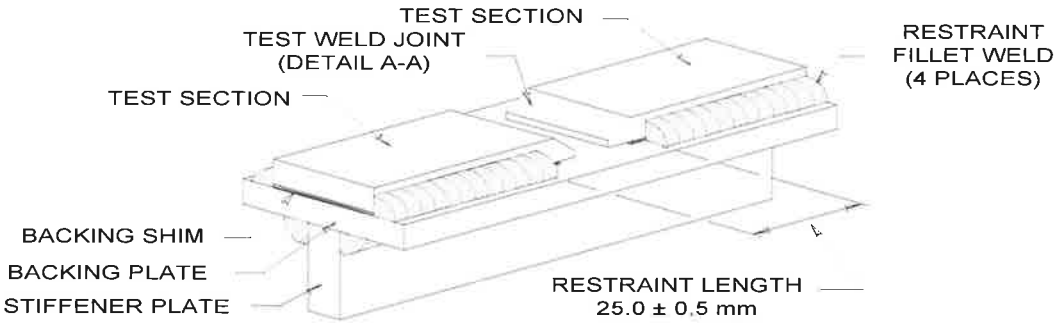
Testing Requirements[2]	Test Sample Nominal Thickness (mm)	
	< 7.3	≥ 7.3
Preheat Temperature (°C)	60±1	75±1
Electrode Classification	E55010-G (E8010-P1)[1]	E55010-G (E8010-P1)[1]
Electrode Diameter (mm)	3.2	4.0
Heat Input (kJ/mm)	0.55 - 0.65	0.65 - 0.75
Typical Welding Parameters	100 - 125 A 23 - 25 V 300 mm/min.	130 - 140 A 22 - 24 V 300 mm/min.
Minimum Weld Throat Thickness of each Section (mm)	2.0	2.5
Maximum Allowable Total Cracking Percentage (%)	5	3

Notes:

[1] Approved electrodes: Phoenix Cel-80, Lincoln 70+, Bohler Fox Cel 85

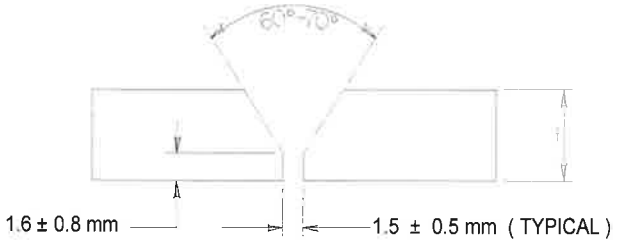
[2] The same supplier and consumable manufacturer's traceability number (heat number, batch number or both) shall be used for a series of tests.

CAUTION: Discretion is advised to the Manufacturer and/or test lab that the use of aged electrodes may affect test results.



NOTE:

1. SEE TABLE 1 FOR DIMENSIONS NOT SHOWN.
2. RUN ON/OFF TABS (NOT SHOWN) SHALL BE TACK WELDED TO BACKING PLATE ONLY.
3. BACKING SHIMS ARE PLACED BETWEEN TEST PLATES AND BACKING PLATES.



Test Weld Joint - Detail A-A

Figure Q-1: Modified WIC Test Assembly

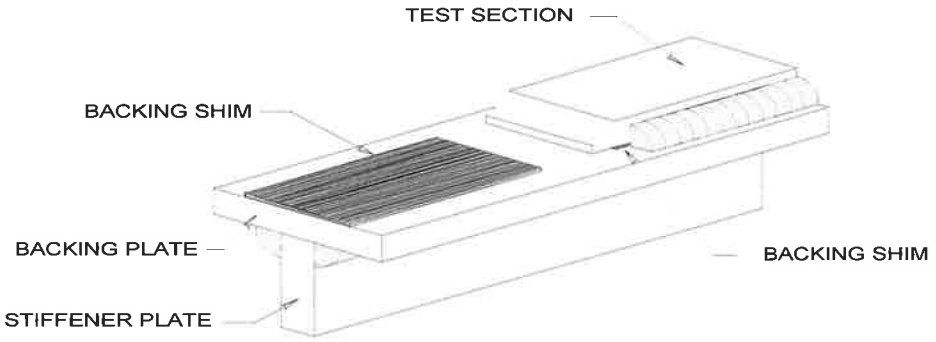


Figure Q-2: Backing Shim Location

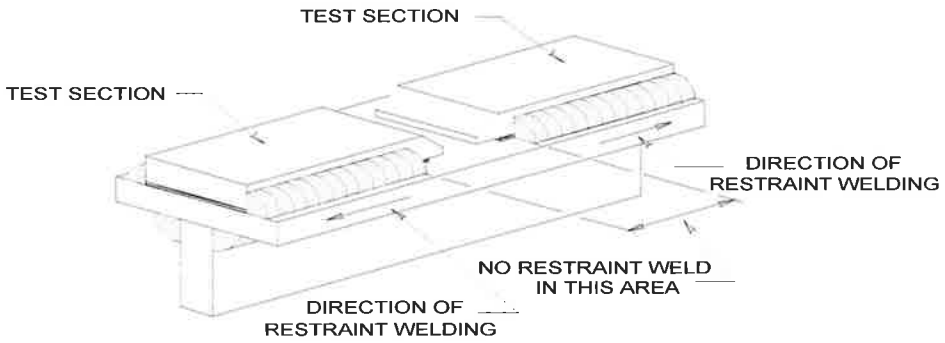
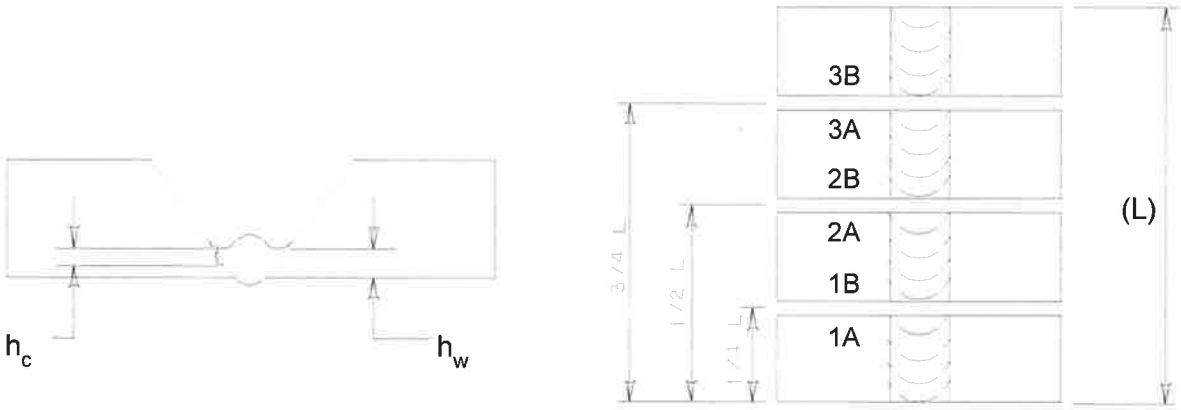


Figure Q-3: Test Section and Restraint Weld Location



NOTE:

1. TEST WELD BEAD SHALL EXHIBIT COMPLETE ROOT PENETRATION AND FUSION.
2. IF h_w IS DIFFERENT ON THE 2 SIDES OF THE WELD USE THE MINIMUM VALUE.
3. (L) - TEST WELD LENGTH
4. h_w - DEPTH OF WELD
5. h_c - DEPTH OF CRACKING

Figure Q-4: Weld Specimen Sectioning

PURPOSE

The purpose of this Specification is to identify the requirements for tightening flange bolts and is intended to be used by those performing the installation of a flanged joint.

SCOPE / APPLICABILITY

This Specification applies to tightening of new and existing flange bolts in all TransCanada facilities such as:

- pumping stations
- compressor stations
- meter stations
- pipelines
- power facilities

This Specification also applies to piping with the following characteristics:

- diameter NPS 1/2 to NPS 48
- pressure classes ANSI 150 (PN20), 300(PN50), 600(PN100), 900(PN150), 1500 (PN250) and 2500 (PN420)
- operating temperatures up to and including 120°C (248°F)
- ASME B16.5 flanges
- ASME B16.47 flanges
- CSA Z245.12 flanges

Requirements for joint tightening of flanges that are not ASME B16.5, ASME B16.47 or CSA Z245.1 flanges shall be determined by the Company Mechanical Engineer.

This Specification does not apply to (consult the Company Mechanical Engineer if encountered):

- pressurized joints/flanges (hot torqueing)
- flat face flanges
- valve bonnets (control valve, gate valve or check valve)
- rotating equipment suction and discharge flanges
- equipment anchor bolting
- structural flanges
- special applications (e.g., for orifice meters, refer to manufacturer's specification)

- use of Superbolt/Supernuts

Within this Specification, TransCanada is referred to as the Company.

Within this Specification, the following terms and definitions apply for requirements:

- Shall—expresses a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard. Shall is not a recommendation but a requirement. A variance may be requested but is unlikely to be granted.
- Should—expresses a strong preference, recommendation or that which is advised, but not required.
- Must—denotes a requirement of the Company, for which no deviation or variance would be granted.
- May—expresses an option or that which is permissible within the limits of the standard.
- Consider—assumes that a competent person will evaluate options to fulfill the intent of the requirement and make a documented decision supported by evidence to ensure protection of people, equipment and the environment by achieving the appropriate level of functional integrity.

Wherein the Manufacturer's literature, governmental or regulatory requirements conflict with this Specification, the more stringent requirement shall govern.

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1 GLOSSARY

ASME

American Society of Mechanical Engineers

Coefficient of Friction (f)

The ratio of the force of friction between two bodies and the force pressing them together.

CSA

Canadian Standards Association

Hammer Wrench

A wrench designed to be struck by a hammer on the anvil area in order to loosen frozen fasteners or to set and tighten fasteners. Also known as a striking wrench.

Hydraulic Tensioner

A machine that utilizes hydraulic pressure to put longitudinal tension (stretch) onto studs. While the pressure is applied at the value indicated on the accompanying chart, the stud nuts are hand tightened against the flanges. When the pressure is released, the tension remaining on the stud is equivalent to the pressure that would have been created by rotating the nut to the pre-determined torque value.

Hydraulic Torque Wrench

A machine that utilizes hydraulic pressure to rotate the nuts on studs or bolts. The pressure shown on the gauge can be converted to a torque value by utilizing the chart that accompanies the machine.

Insulating Gasket

A gasket that isolates two mating flanges to reduce the likelihood of creating a galvanic cell which would result in corrosion of the flanges and piping. It is one part of an Insulation Set. See also Insulation Set.

Insulation Set

Insulating materials that reduce the likelihood of galvanic corrosion between flanges and prevent the flow of electrostatic charge to reduce sparking in hazardous environments. The set is comprised of an insulation gasket and each bolt is insulated with a pair of insulating sleeves, a fibre and a metal washer. See also Insulating Gasket.

Pneumatic Torque Wrench

A torque wrench machine that uses pneumatic pressure. See also Hydraulic Torque Wrench.

Raised Face (RF) Flange

A flange on which the gasket surface is raised above the bolting circle face. This face type allows for a wide variety of gasket designs to be installed. The purpose of the raised face flange is to concentrate more pressure on a smaller gasket area and thereby increase the pressure containment capability of the joint.

Ring Type Joint (RTJ) Flange

A flange typically used in high pressure (Class 600 and higher ratings) and/or high temperature services (above 427°C/800°F). The RTJ flange has a groove cut into the face which holds steel ring gaskets. Tightening the bolts allows the flanges to seal by compressing the gaskets between the flanges into the grooves. The gasket material is deformed thus making intimate contact inside the grooves, creating a metal-to-metal seal. A RTJ flange may have a raised face with a ring groove machined into it, though this raised face does not serve as part of the sealing mechanism.

SAE

Society of Automotive Engineers

2 GLOBAL REQUIREMENTS

2.1 General Requirements

2.1.1 All materials shall conform to the following Company material specifications:

- *TES-MATL-MD1 Piping System Materials for Pipeline, Compression and Metering Facilities (*EDMS No. 3764909)
- *TES-MATL-MD1-L Piping System Materials for Pipeline, Pump, Metering and Terminal Facilities (CDN-US-MEX) (EDMS No.* 7935312*)*
- *TES-MATL-MD1-US Piping System Materials for Pipeline, Compression and Metering Facilities (CDN-US-MEX) (*EDMS No. 4471280*)*
- *TES-MATL-MD2-US Piping System Materials for Pipeline, Compression and Metering Facilities Design to -20°F (US-MEX) (EDMS No. 7073999)*

2.2 Pre-Job Planning Requirements

2.2.1 The flange tightening activity shall be discussed prior to assembly. The involved workers shall review appropriate drawings to identify the flanges that need to be installed or maintained.

2.2.2 All flange tightening personnel shall be qualified.

2.2.2.1 For US installations, personnel must be qualified as per relevant company operator qualification.

2.2.3 Flange tightening personnel shall be accountable for ensuring the safety and quality of the flange assembly/tightening work.

2.2.4 The *Flange Installation Quality Control Form* (EDMS No. 7279729) shall be completed for each flange assembled, NPS 12 and above, reviewed by the Company Inspector and provided in the turnover package.

2.2.5 For projects, with multiple flange assemblies of NPS 12 or greater, it is recommended a Flange Torque Map be created. If a Flange Torque Map is created, each flange shall be assigned a unique number, the unique number shall be indicated on the Flange Installation Quality Control Form (EDMS No. 7279729) and be relayed onto a table, sketch or isometric indicating the location of the flange assembly ensuring traceablity.

2.2.6 The following shall be verified prior to flange bolting:

- flange size
- flange pressure class/rating
- flange configuration
- number of studs and stud grade

- stud diameter and stud lengths (flanges being tightened with a hydraulic tensioner require extra-long studs as identified in Appendix C, Appendix D, Appendix E and Appendix F)
- nut size and grade
- appropriate tightening method is selected (manual or hydraulic torque wrench, hydraulic tensioning)
- torque values specific to the type of studs and lubrication used
- adequate lubrication (see section 3.7)
- type of gasket to be used
- hardened steel washers required (and supplied) with insulation kits
- SAE through hardened through washers may be considered for pitted or damaged flanges

3 REQUIREMENTS FOR RAISED FACE AND RTJ FLANGES

Unless otherwise noted, the flange bolting personnel performing the joint installation shall perform the following activities.

3.1 General Requirements

3.1.1 Inspect flange faces for damage (e.g., dents, scratches, dirt, contaminants, other deleterious material, etc.).

3.1.2 If damage is observed, contact the Company Mechanical Design Engineer or Materials Engineering prior to proceeding with flange usage. See ASME PCC-2 for flange repair if required.

3.1.3 Align flange to ensure adequate clamping stress for seating the gasket and prevent damage to the gasket during installation. Ensure flange faces are lined up in all directions (axial with the pipe, planar, and torsional) to eliminate stress in the flange joint. Ensure flange joint alignment is in accordance with Appendix H and ASME-PCC-1.

3.1.4 Ensure a metal-to-metal contact of Ring Type Joint (RTJ) flange groove and gasket ring for proper sealing.

3.1.5 Preferred practice is to use washers on both sides of the flange joint for each bolt-up.

3.1.6 For flanges requiring insulating gasket sets, use sleeves, fiber washers and metal washer to insulate one flange from the other.

3.1.7 For installations where unique conditions such as high temperature or high vibration may exist, re-torqueing may be required. Consult with the Company Mechanical / Stress Engineer.

3.2 Gaskets

3.2.1 Use only new gaskets of the correct type, material and size for the application. *Do not install a previously used gasket.*

3.2.2 Refer to the *TES-CP-MS (CDN-US) Cathodic Protection Materials Specification* (EDMS No. 3670944) for acceptable insulating gaskets.

3.2.3 Check new gaskets for damage and discard if damaged.

3.2.4 Do not lubricate gaskets as this will prevent proper sealing.

3.2.5 Handle gaskets containing asbestos using appropriate safety procedures and personal protective equipment. Refer to the *Asbestos Management Procedures Canada and Mexico (EDMS No.* 3671361*)* and *Asbestos Management Procedures U.S. (EDMS No.* 3864096*)* for more information on working with gaskets that contain asbestos.

3.2.6 Do not use power tools (e.g., grinders) to remove asbestos gaskets.

3.2.7 Use specialized cleaning methods for cleaning the flange face.

3.2.8 Refer to the below tables for gasket applications and type examples. All gasket materials shall conform to the Company's material specifications in accordance with section 2.1.1.

Table 3-1: Raised Face Gaskets for Class 150-2500

Application	Type / Material	Trade Names
Regular Flange Sealing	Spiral Wound w/ Inner and Outer Carbon Steel Ring + non-asbestos winding	Flexitallic Style CGI Garlock RWI (Class 600 or less)
	Compressed Fiber	Garlock HT 9850 (Class 600 or less)
Insulation Kit	Flat Ring (Type F) / Fiber Reinforced Epoxy	See section 9.1.1 of TES-CP-MS Corrosion Prevention Material Specification (EDMS No. 003670944)

Table 3-2: Ring Type Joint Gaskets for Class 600-2500

Application	Type / Material	Trade Names
Ring Joint Flange Sealing	Soft, Solid Metal Ring-Type Joint Gasket	
Insulating Kit	Ring-Type (Type F) / PTFE	GPT VCS

3.2.9 Ring gaskets are available in oval or octagonal configurations. Octagonal configurations should not be used on older flanges that have a rounded profile at the bottom of the gasket groove. For such cases, an oval configuration should be used to ensure proper joint contact. The oval configuration fits all ring joints whereas the octagonal configuration fits only new ring joints. The octagonal design is considered more reliable and should be used for all new ring joints.

3.3 Studs/Bolts

3.3.1 Studs may be re-used provided the threads show no damage or elongation, are free of debris, paint and rust, and a new nut is able to turn the entire length of the stud by hand. Discard any studs and bolts that do not satisfy all of these requirements.

3.3.2 Where common grade fasteners are used (e.g., ASTM A320 Gr7 studs and ASTM A194 Gr4 or Gr7 nuts), new bolts and nuts should be used for diameters of 1-1/8 in. and smaller.

3.3.3 Teflon coated studs may be re-used provided they are lubricated in accordance with section 3.7 and torqued in accordance with lubricated target torque values found in the appendix. Do not use Teflon target torque values on re-used Teflon coated studs.

3.3.4 Ensure studs/bolts used at coastal facilities and pipelines are coated with either Xylan, Teflon, or as specified by the project.

3.3.5 At coastal facilities and pipelines, use new bolts with each installation.

3.4 Nuts

3.4.1 Nuts may be re-used provided threads are not damaged and all dirt and debris is removed from the nut threads. Verify threads are not damaged by ensuring they run freely onto the stud. Discard any nuts that are damaged.

3.4.2 Lubricate between face of nut and flange, see section 3.7 for lubrication details.

3.5 Washers

3.5.1 If steel washers are to be installed, lubricate between the face of the nut and the washer on the side of the flange torque is being applied.

3.5.2 Use fully hardened SAE steel washers. Do not use surface hardened steel.

3.6 Requirements when Using Torque/Tensioning Equipment

3.6.1 When using torque equipment, ensure stud bolts installed in the flange joint extend a minimum of one to three threads past the nut on each side of the flange.

3.6.2 When using bolt tensioning equipment, ensure the stud on the working side of the flange extends 1.5 times the diameter of the stud bolt past the nut. This allows proper thread engagement onto the bolt tensioner (e.g., 2 in. stud bolt would have 3 in. thread extending past the nut face).

3.7 Lubrication

3.7.1 Appropriate lubrication must be used on all studs not coated with Teflon or Xylan.

3.7.2 Selected lubricants shall achieve a coefficient of friction ≤ 0.11 or a nut factor (K) ≤0.15. Examples of such lubricants which meet Mil-Spec 907A include:

- molybdenum-disulfide grease
- Bostik Never-Seez
- Fastorq 70+

- Jet-Lube MP-50
- Sweeney 503
- Loctite Moly Paste

3.7.3 Teflon or Xylan coated studs do not require lubricant and have a coefficient of friction of approximately 0.055 and 0.04 respectively for an estimated nut factor of K = 0.10. See section 3.3 for re-use of Teflon or Xylan coated stud bolts.

3.8 Disassembly of Flanged Joints

3.8.1 Confirm that the line is depressurized and bled off of any gas or oil before starting disassembly on any flanged joint.

3.8.2 On large joints, great energy may be stored in the flange unit components. Follow safe unbolting practices when disassembling flange joints as described below:

- Gradually untighten nuts in a star pattern as per Appendix G.
- Leave the nuts loosened on the studs until the joint has been separated.
- Anticipate pipe spring.

3.8.3 Ensure proper tag and lockout procedures are followed (see *Lockout and Tagout Procedure* (EDMS No. 3834759)).

4 TIGHTENING, TOOL SELECTION AND TOOL USE REQUIREMENTS

Unless otherwise noted, the Contractor or personnel performing the joint installation shall perform the following activities.

4.1 General Tightening Requirements

4.1.1 Tighten each of the studs using the sequence shown in Appendix G. Mark each stud with chalk or a grease pencil as it is tightened so it is easy to verify that all studs have been tightened.

4.1.2 Achieve the final torque value by tightening the flange in five stages as follows:

1. Initial recommended setting: 25% of maximum torque value
2. Second recommended setting: 50% of maximum torque value
3. Third recommended setting: 75% of maximum torque value
4. Full setting: 100% of maximum torque value
5. Check pass of 100% of target torque in clockwise fashion around the flange

4.1.3 Ensure manual and hydraulic/pneumatic torque wrenches as well as the pressure gauges on the pneumatic pump for the hydraulic tensioners are calibrated annually. Provide calibration records, including before and after reading for torque wrenches.

4.1.4 Flanges to be installed below ground shall be re-torqued as an additional check post achieving 100% of target torque after 4 hours (similar to a Check pass mentioned in section 4.1.2).

4.2 Tool Selection

4.2.1 Refer to Appendix A (Class 150/PN20), Appendix B (Class 300/PN50), Appendix C (Class 600/PN100), Appendix D (Class 900/PN150), Appendix E (Class 1500/PN250) and Appendix F (Class 2500/PN420) for the proper tightening tool and for the torque values to use with each tool.

4.3 Hammer Wrench

4.3.1 Use hammer wrenches only for loosening nuts.

4.3.2 Do not use hammer wrenches for completing the final tightening.

4.3.3 Do not use hammer wrenches for offshore/subsea applications.

4.4 Manual Torque Wrench

4.4.1 Use manual torque wrenches only for tightening bolts.

4.4.2 Do not use manual torque wrenches for loosening bolts.

4.5 Hydraulic/Pneumatic Torque Wrench

4.5.1 Hydraulic/pneumatic torque wrenches are preferred for tightening bolts and can also be used for loosinging bolts.

4.6 Hydraulic Tensioner

4.6.1 Hydraulic tensioners are preferred for tightening Class 600 (PN100), Class 900 (PN150) and Class 1500 (PN250) flanges NPS 16 and larger.

4.6.2 For the required bolt loading, see Appendix C (Class 600/PN100), Appendix D (Class 900/PN150), Appendix E (Class 1500/PN250) and Appendix F (Class 2500/PN420).

4.6.3 Use multiple tools for simultaneous tightening of bolts with diameters M20 (3/4 in.) and larger.

4.6.4 Calibrate pressure gauges on the pneumatic pump for the hydraulic tensioners annually. Keep records on file and provide them to the Company for project files.

5 VARIANCES

Any deviation shall follow the TransCanada Management of Change (MOC) Variance Procedure. External vendors must contact the TransCanada Project Engineer for variance approval.

6 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These

documents are detailed below in Table 6-1. Use the latest document revision, unless otherwise approved by TransCanada.

Table 6-1: External and Internal References

Document No.	Title
Regulatory Codes	
CFR 192.147	Design of Pipeline Components – Flanges and Flange Accessories
CFR 195.118	Design Requirements – Fitting
CFR 195.126	Design Requirements – Flange Connection
CFR 195.422	Operations and Maintenance – Pipeline Repairs
CSA Z662, 5.2	Steel Material and Gaskets
CSA Z662, 5.2.7	Bolting
CSA Z662, 5.2.8	Gaskets
CSA Z662, 10.5	Operating and Maintenance Procedures
Industry Codes and Standards	
ASME PCC-1 2013	Guideline for Pressure Boundary Bolted Flange Joint Assembly
ASME PCC-2 2015	Repair of Pressure Equipment and Piping
ASME B16.5	Pipeline Flanges and Flanged Assemblies
ASME B16.47 - 2011	Large Diameter Steel Flanges
ASME B18.2.2 - 2015	Nuts for General Applications
ASME BPVC	Section VIII Division 1 Mandatory Appendix 2
Internal References – Documents Referenced by this Standard / Specification	
EDMS No. 3671361	Asbestos Management Procedures Canada and Mexico
EDMS No. 3864096	Asbestos Management Procedures U.S.
EDMS No. 3670944	TES-CP-MS Cathodic Protection Materials Specification (CDN-US)
EDMS No. 7279729	Flange Installation Quality Control Form
EDMS No. 3834759	Lockout and Tagout Procedure
EDMS No. 3670944	TES-CP-MS Corrosion Prevention Material Specification

Document No.	Title
EDMS No. 3764909	TES-MATL-MD1 Piping System Materials for Pipeline, Compression and Metering Facilities
EDMS No. 7935312	TES-MATL-MD1-L Piping System Materials for Pipeline, Pump, Metering and Terminal Facilities (CDN-US-MEX)
EDMS No. 4471280	TES-MATL-MD1-US Piping System Materials for Pipeline, Compression and Metering Facilities (CDN-US-MEX)
EDMS No. 3671966	TES-FLGE-LD Specification for Carbon Steel Buttwelding Flanges

7 DOCUMENT HISTORY

Rev. No.		
03	**Description**	**Effective Date**
	Revised to reflect the new engineering specifications template, to ensure compliance to CSA Z662-15 and to update bolt torques in the Appendices.	2017-Feb-16
	Rationale Statement	**Responsible Engineer**
	This document was developed to address the following requirements: • Consolidation of specifications. The following specifications/documents have been combined into this document: ▪ TES-MECH-FBT Specification for Flange Assembly (CDN-US-MEX) Rev. 02 ▪ TOP: Flange Bolt tightening procedures • Formatted to the new engineering specifications template • Revised torque values and addied additional NPS sizes for appendix tables and added torque tables for ANSI 1500 and ANSI 2500 class flanges	Jason Lu
	Impact Assessment Summary	**Team Owner**
	N/A	Jason Lu

8 DESCRIPTION OF CHANGE

Section	Description of Change
Regulatory	
N/A	N/A
Industry Standards	
N/A	N/A
General	
N/A	This Specification is a new document.

9 APPROVALS

APPROVALS		
Originator: David Scalzo, P.Eng. Design Services	Signature	Feb. 6, 2017 Date
Reviewer: Melissa Kuntel, P.Eng. Pipeline Engineering	Signature	Feb. 7, 2017 Date
Reviewer: Trent Bertholet, ~~ Welding & Materials Engineering	Signature	Feb 9, 2017 Date
Reviewer: Travis Dobbyn, Construction Manager CMS Projects & Operation US & Mexico	Signature	Feb 8/2017 Date
Reviewer: Dmitry Ryapolov, P.Eng. Valve Specialist, Technical Services	Signature #84006	Feb 9, 2017 Date
Responsible Engineer: Jason Lu, P. Eng. Design Services	Signature FEB.09 2017 Date	PROFESSIONAL ENGINEER ALBERTA JASON S. LU APEGA Permit to Practice P7100
Management Endorsement: Muhammad Riaz, Manager Design Services	Signature	Feb. 13th, 2017 Date

APPENDIX A ANSI 150 (PN20) Bolt Tightening Requirements

Flange Size		Stud Bolts		Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method		Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	**Raised Face** Minimum Stud Length[3,4] In. (mm)	Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
0.5	4	1/2 (12.7)	2-3/4 (70)	7/8 (22)	P		35	25
0.75	4	1/2 (12.7)	3 (75)	7/8 (22)	P		35	25
1	4	1/2 (12.7)	3 (75)	7/8 (22)	P		35	25
1.25	4	1/2 (12.7)	3-1/4 (85)	7/8 (22)	P		35	25
1.5	4	1/2 (12.7)	3-1/4 (85)	7/8 (22)	P		35	25
2	4	5/8 (15.9)	3-3/4 (95)	1-1/16 (27)	P		60	45
2.5	4	5/8 (15.9)	4 (100)	1-1/16 (27)	P		60	45
3	4	5/8 (15.9)	4 (100)	1-1/16 (27)	P		65	45
4	8	5/8 (15.9)	4 (100)	1-1/16 (27)	P		60	45
6	8	3/4 (19.1)	4-1/2 (150)	1-1/4 (32)	P		105	80
8	8	3/4 (19.1)	4-3/4 (120)	1-1/4 (32)	P		110	80
10	12	7/8 (22.23)	5 (125)	1-7/16 (36.5)	P		165	120
12	12	7/8 (22.23)	5-1/4 (135)	1-7/16 (36.5)	P		165	120
14	12	1 (25.4)	5-3/4 (145)	1-5/8 (41)	P		245	180
16	16	1 (25.4)	5-3/4 (145)	1-5/8 (41)	P		245	180
18	16	1-1/8 (28.6)	6-1/4 (160)	1-13/16 (46)	P	A	355	260
20	20	1-1/8 (28.6)	6-3/4 (170)	1-13/16 (46)	P	A	355	260
24	20	1-1/4 (31.8)	7-1/4 (185)	2 (50)	A	P	500	365
26	24	1-1/4 (31.8)	9-1/2 (240)	2 (50)	A	P	500	365
30	28	1-1/4 (31.8)	10 (255)	2 (50)	A	P	500	365
34	32	1-1/2 (38.1)	11-1/2 (290)	2-3/8 (61)	A	P	885	650
36	32	1-1/2 (38.1)	12 (305)	2-3/8 (61)	A	P	885	650
42	36	1-1/2 (38.1)	12-1/2 (320)	2-3/8 (61)	A	P	885	650
48	44	1-1/2 (38.1)	13-1/2 (345)	2-3/8 (61)	A	P	885	650

Notes:

1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2. The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.3 was selected for Class 150 (Bolt stress equals 31,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers.
4) If planning to use hydraulic tensioning add 1.5x Stud Diameter to the minimum recommended stud length. Lstud = Lmin + 1.5 x Dia.stud

APPENDIX B ANSI 300 (PN50) Bolt Tightening Requirements

Flange Size		Stud Bolts		Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method		Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	**Rasied Face** Minimum Stud Length[3,4] In. (mm)	Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
0.5	4	1/2 (12.7)	3 (75)	7/8 (22)	P		35	25
0.75	4	5/8 (15.9)	3-1/2 (90)	1-1/16 (27)	P		60	45
1	4	5/8 (15.9)	3-1/2 (90)	1-1/16 (27)	P		60	45
1.25	4	5/8 (15.9)	3-3/4 (95)	1-1/16 (27)	P		60	45
1.5	4	3/4 (19.1)	4 (100)	1-1/4 (32)	P		105	80
2	8	5/8 (15.9)	4 (100)	1-1/16 (27)	P		60	45
2.5	8	3/4 (19.1)	4-1/2 (115)	1-1/4 (32)	P		105	80
3	8	3/4 (19.1)	4-1/4 (110)	1-1/4 (32)	P		105	80
4	8	3/4 (19.1)	4-1/2 (115)	1-1/4 (32)	P		105	80
6	12	3/4 (19.1)	5-1/4 (135)	1-1/4 (32)	P		105	80
8	12	7/8 (22.23)	6 (150)	1-7/16 (37)	P		165	120
10	16	1 (25.4)	6-3/4 (170)	1-5/8 (41)	P		245	180
12	16	1-1/8 (28.6)	7-1/4 (185)	1-13/16 (46)	P	A	355	260
14	20	1-1/8 (28.6)	7-1/2 (190)	1-13/16 (46)	P	A	355	260
16	20	1-1/4 (31.8)	8 (205)	2 (50)	A	P	500	365
18	24	1-1/4 (31.8)	8-1/4 (210)	2 (50)	A	P	500	365
20	24	1-1/4 (31.8)	8-1/2 (215)	2 (50)	A	P	500	365
24	24	1-1/2 (38.1)	9-1/2 (240)	2-3/8 (61)	A	P	885	650
26	28	1-5/8 (41.3)	11-1/2 (290)	2-9/16(65)	A	P	1140	835
30	28	1-3/4 (44.5)	12-3/4 (325)	2-3/4 (70)	A	P	1440	1060
34	28	1-7/8 (47.63)	13-3/4 (350)	2-15/16 (75)	A	P	1785	1310
36	32	2 (50.8)	14-1/4 (360)	3-1/8 (79)	A	P	2185	1605
42	32	1-5/8 (41.3)	14-1/2 (370)	2-9/16 (61)	A	P	1310	875
48	32	1-7/8 (47.63)	16-1/4 (415)	2-15/16 (75)	A	P	1785	1310

Notes:

1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2.The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.3 was selected for Class 300 (Bolt stress equals 31,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers.
4) If planning to use hydraulic tensioning add 1.5x Stud Diameter to the minimum recommended stud length. Lstud = Lmin + 1.5 x Dia.stud

APPENDIX C ANSI 600 (PN100) Bolt Tightening Requirements

Flange Size		Stud Bolts			Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method			Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	Minimum Stud Length[3,4] In. (mm)		Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Hydraulic Tensioning	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
			Raised Face	RTJ						
0.5	4	1/2 (12.7)	3-1/2 (90)	4 (100)	7/8 (22)	P			50	40
0.75	4	5/8 (15.9)	4 (100)	4-1/2 (115)	1-1/16 (27)	P			100	75
1	4	5/8 (15.9)	4 (100)	4-1/2 (115)	1-1/16 (27)	P			100	75
1.25	4	5/8 (15.9)	4-1/4 (110)	4-3/4 (120)	1-1/16 (27)	P			100	75
1.5	4	3/4 (19.1)	4-3/4 (120)	5-1/4 (135)	1-1/4 (32)	P			170	125
2	8	5/8 (15.9)	4-3/4 (120)	5-1/4 (135)	1-1/16 (27)	P			100	75
2.5	8	3/4 (19.1)	5-1/4 (135)	5-3/4 (145)	1-1/4 (32)	P			170	125
3	8	3/4 (19.1)	5-1/2 (140)	6 (150)	1-1/4 (32)	P			170	125
4	8	7/8 (22.23)	6-1/4 (160)	6-3/4 (170)	1-7/16 (37)	P			270	200
6	12	1 (25.4)	7-1/4 (185)	7-3/4 (195)	1-5/8 (41)	P	A		400	295
8	12	1-1/8 (28.6)	8 (205)	8-1/2 (215)	1-13/16 (46)	P	A		590	435
10	16	1-1/4 (31.8)	9 (230)	9-1/2 (240)	2 (50)	P	A		825	605
12	20	1-1/4 (31.8)	9-1/4 (235)	9-3/4 (250)	2 (50)	P	A		825	605
14	20	1-3/8 (35)	9-3/4 (250)	10-1/4 (260)	2-3/16 (55)	P	A		1120	825
16	20	1-1/2 (38.1)	12-3/4 (325)	13-1/4 (335)	2-3/8 (61)		A	P	1475	1080
18	20	1-5/8 (41.3)	13-3/4 (350)	14-1/4 (360)	2-9/16 (65)		A	P	1900	1395
20	24	1-5/8 (41.3)	14-1/4 (360)	14-3/4 (375)	2-9/16 (65)		A	P	1900	1395
24	24	1-7/8 (47.6)	16-1/4 (415)	16-3/4 (425)	2-15/16 (75)		A	P	2975	2185
26	28	1-7/8 (47.6)	17 (430)	17-1/2 (445)	2-15/16 (75)		A	P	2975	2185
30	28	2 (50.8)	18 (455)	18-1/2 (470)	3-1/8 (79)		A	P	3640	2670
34	28	2-1/4 (57.2)	19-1/2 (495)	20 (510)	3-1/2 (89)		A	P	5255	3855
36	28	2-1/2 (63.5)	20-1/2 (520)	21 (535)	3-7/8 (98)		A	P	7295	5350
42	28	2-1/2 (63.5)	24 (610)	24-1/2 (620)	3-7/8 (98)		A	P	7295	5350
48	32	2-3/4 (69.9)	26-1/2 (675)	27 (685)	4-1/4 (108)		A	P	9800	7190

Notes:

1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2.The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.5 was selected for Class 600 (Bolt stress equals 52,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers. For RTJ flanges an additional a half inch was added to the stud length to accomidate the ringed gasket.
4) Extra long studs are used for NPS 16 to NPS 48 to accommodate the preferred use of hydraulic tensioning; a 1.5x Stud Diameter was added to the minimum stud length (Lstud = Lmin + 1.5 x Dia.stud).

APPENDIX D ANSI 900 (PN150) Bolt Tightening Requirements

Flange Size		Stud Bolts			Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method			Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	Minimum Stud Length[3,4] In. (mm)		Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Hydraulic Tensioning	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
			Raised Face	RTJ						
0.5	4	3/4 (19.1)	4-3/4 (120)	5-1/4 (135)	1-1/4 (32)	P			170	125
0.75	4	3/4 (19.1)	5 (125)	5-1/2 (140)	1-1/4 (32)	P			170	125
1	4	7/8 (22.23)	5-1/2 (140)	6 (150)	1-7/16 (37)	P			270	200
1.25	4	7/8 (22.23)	5-1/2 (140)	6 (150)	1-7/16 (37)	P			270	200
1.5	4	1 (25.4)	6 (150)	6-1/2 (165)	1-5/8 (41)	P			400	295
2	8	7/8 (22.23)	6-1/4 (160)	6-3/4 (170)	1-7/16 (37)	P			270	200
2.5	8	1 (25.4)	6-3/4 (170)	7-1/4 (185)	1-5/8 (41)	P			400	295
3	8	7/8 (22.23)	6-1/4 (160)	6-3/4 (170)	1-7/16 (37)	P			270	200
4	8	1-1/8 (28.6)	7-1/4 (185)	7-3/4 (195)	1-13/16 (46)	P	A		590	435
6	12	1-1/8 (28.6)	8 (205)	8-1/2 (215)	1-13/16 (46)	P	A		590	435
8	12	1-3/8 (34.9)	9-1/4 (235)	9-3/4 (250)	2-3/16 (55)	P	A		1120	820
10	16	1-3/8 (34.9)	9-3/4 (250)	10-1/4 (260)	2-3/16 (55)	P	A		1120	820
12	20	1-3/8 (34.9)	10-1/2 (265)	11 (280)	2-3/16 (55)	P	A		1120	820
14	20	1-1/2 (38.1)	13-1/2 (345)	14 (355)	2-3/8 (60)		A	P	1475	1080
16	20	1-5/8 (41.3)	14-1/4 (360)	14-3/4 (375)	2-9/16 (65)		A	P	1900	1395
18	20	1-7/8 (47.63)	16 (405)	16-1/2 (420)	2-15/16 (75)		A	P	2975	2185
20	20	2 (50)	17 (430)	17-1/2 (445)	3-1/8 (79)		A	P	3640	2670
24	20	2-1/2 (63.5)	21-1/4 (540)	21-3/4 (550)	3-7/8 (98)		A	P	7295	5350
26	20	2-3/4 (70)	22-1/2 (570)	23 (585)	4-1/4 (108)		A	P	9795	7185
30	20	3 (76.2)	24-1/4 (615)	24-3/4 (630)	4-5/8 (143)		A	P	12815	9400
34	20	3-1/2 (88.9)	27-1/4 (690)	27-3/4 (705)	5-3/8 (137)		A	P	20590	15100
36	20	3-1/2 (88.9)	27-3/4 (705)	28-1/4 (720)	5-3/8 (137)		A	P	20590	15100
42	24	3-1/2 (88.9)	30-1/2 (775)	31 (785)	5-3/8 (137)		A	P	20590	15100
48	24	4 (101.6)	34-1/4 (870)	34-3/4 (885)	6-1/8 (156)		A	P	31005	22740

Notes:

1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2.The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.5 was selected for Class 900 (Bolt stress equals 52,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers. For RTJ flanges an additional a half inch was added to the stud length to accomidate the ringed gasket.
4) Extra long studs are used for NPS 14 to NPS 48 to accommodate the preferred use of hydraulic tensioning; a 1.5x Stud Diameter was added to the minimum stud length (Lstud = Lmin + 1.5 x Dia.stud).

APPENDIX E ANSI 1500 (PN250) Bolt Tightening Requirements

Flange Size		Stud Bolts Nominal Size			Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method			Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	Minimum Stud Length[3,4] In. (mm)		Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Hydraulic Tensioning	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
			Raised Face	RTJ						
0.5	4	3/4 (19.1)	4-3/4 (120)	5-1/4 (135)	1-1/4 (32)	P			170	125
0.75	4	3/4 (19.1)	5 (125)	5-1/2 (140)	1-1/4 (32)	P			170	125
1	4	7/8 (22.2)	5-1/2 (140)	6 (150)	1-7/16 (37)	P			270	200
1.25	4	7/8 (22.2)	5-1/2 (140)	6 (150)	1-7/16 (37)	P			270	200
1.5	4	1 (25.4)	6 (150)	6-1/2 (165)	1-5/8 (41)	P			400	295
2	8	7/8 (22.2)	6-1/4 (160)	6-3/4 (170)	1-7/16 (37)	P			270	200
2.5	8	1 (25.4)	6-3/4 (170)	7-1/4 (185)	1-5/8 (41)	P	A		400	295
3	8	1-1/8 (28.6)	7-1/2 (190)	8 (205)	1-13/16 (46)	P	A		590	435
4	8	1-1/4 (31.2)	8-1/4 (210)	8-3/4 (220)	2 (50)	P	A		825	605
6	12	1-3/8 (34.9)	10-3/4 (275)	11-1/4 (285)	2-3/16 (56)	P	A		1120	820
8	12	1-5/8 (41.3)	14-1/2 (370)	15 (380)	2-9/16 (75)		A	P	1900	1395
10	12	1-7/8 (47.6)	16-1/2 (420)	17 (430)	2-15/16		A	P	2975	2185
12	16	2 (50.8)	18-1/4 (465)	18-3/4 (475)	3-1/8 (79)		A	P	3640	2670
14	16	2-1/4 (57.2)	20 (510)	20-3/4 (525)	3-1/2 (89)		A	P	5255	3855
16	16	2-1/2 (63.5)	21-3/4 (550)	22-3/4 (580)	3-7/8 (98)		A	P	7295	5350
18	16	2-3/4 (69.9)	24-1/4 (615)	25-1/2(650)	4-1/4 (108)		A	P	9795	7185
20	16	3(76)	26-1/4 (665)	27-1/4 (690)	4-5/8 (117)		A	P	12815	9400
24	16	3-1/2 (89)	30 (760)	31-1/4 (795)	5-3/8 (137)		A	P	20590	15100

Notes:

1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2.The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.5 was selected for Class 1500 (Bolt stress equals 52,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers. For RTJ flanges an additional a half inch was added to the stud length to accomidate the ringed gasket.
4) Extra long studs are used for NPS 8 to NPS 24 to accommodate the preferred use of hydraulic tensioning; a 1.5x Stud Diameter was added to the minimum stud length (Lstud = Lmin + 1.5 x Dia.stud).

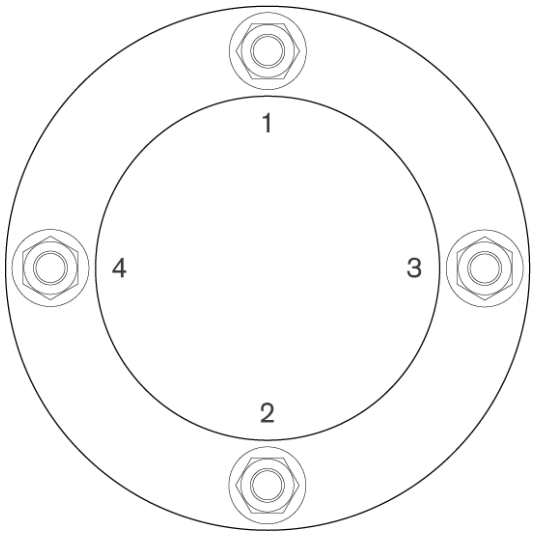
APPENDIX F ANSI 2500 (PN420) Bolt Tightening Requirements

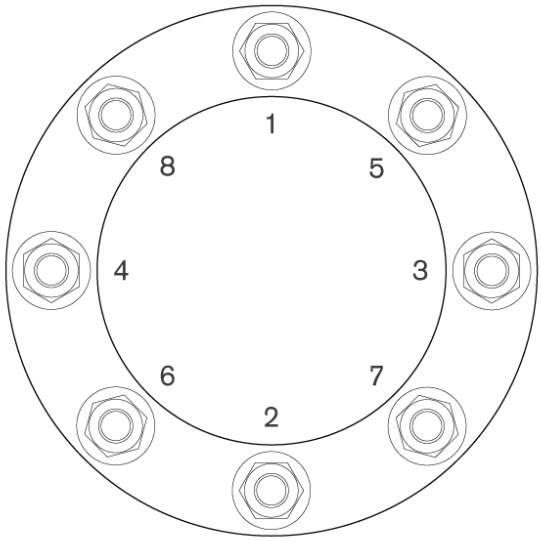
Flange Size		Stud Bolts			Nut Size (O.D.)	Flange Tightening Method P = preferred method A = acceptable method			Torque Values[1, 2]	
NPS	No. of Bolts	Nominal Size Stud Diameter In. (mm)	Minimum Stud Length[3,4] In. (mm)		Nominal Size In. (mm)	Torque Wrench	Hydraulic / Pneumatic Torqueing	Hydraulic Tensioning	Lubricated (ft-lbs) K=0.15	Teflon or Xylan Coated (ft-lbs) K=0.10
			Raised Face	RTJ						
0.5	4	3/4 (19.1)	5-1/4 (135)	5-3/4 (145)	1-1/4 (32)	P			170	125
0.75	4	3/4 (19.1)	5-1/2 (140)	6 (150)	1-1/4 (32)	P			170	125
1	4	7/8 (22.2)	6 (150)	6-1/2 (165)	1-7/16 (37)	P			270	200
1.25	4	1 (25.4)	6-1/2 (165)	7 (180)	1-5/8 (41)	P	A		400	295
1.5	4	1-1/8 (28.6)	7-1/4 (185)	7-3/4 (195)	1-13/16 (46)	P	A		590	435
2	8	1 (25.4)	7-1/2 (190)	8 (205)	1-5/8 (41)	P	A		400	295
2.5	8	1-1/8 (28.6)	8-1/4 (210)	8-3/4 (220)	1-13/16 (46)	P	A		590	435
3	8	1-1/4 (31.2)	9-1/4 (235)	9-3/4 (250)	2 (50)	P	A		825	605
4	8	1-1/2 (38.1)	12-3/4 (325)	13-1/2 (335)	2-3/8 (61)		A	P	1475	1080
5	8	1-3/4 (44.5)	15 (380)	15-1/2 (395)	3-1/8 (79)		A	P	2395	1760
6	8	2 (50.8)	17 (430)	17-1/2 (445)	3-1/8 (79)		A	P	3640	2670
8	12	2 (50.8)	18-1/2 (470)	19 (485)	3-7/8 (98)		A	P	3640	2670
10	12	2-1/2 (63.5)	23-1/2 (595)	24-1/4 (615)	4-1/8 (105)		A	P	7295	5350
12	12	2-3/4 (69.9)	26 (660)	26-3/4 (680)	1-1/4 (32)		A	P	9795	7185

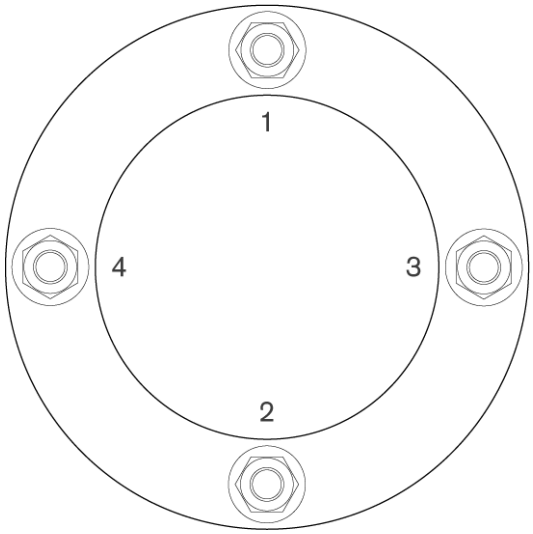
Notes:

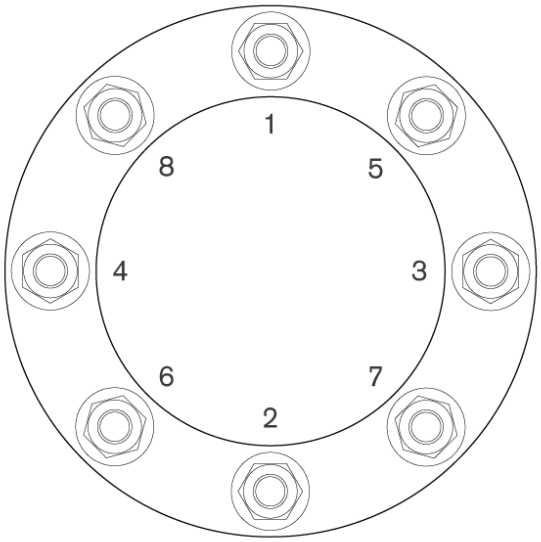
1) Bolt loads calculated using both ASME PCC-1-2013 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly) Appendix J and ASME BPVC Section VIII Division 1 Mandatory Appendix 2.The greater bolt load generated from the two methods was chosen. Torque values calculated using ASME PCC-1-2013 Appendix K, where K equals the coefficient of friction of the lubricant/coating plus 0.04.
2) A percent utilization factor for material yield strength of 0.5 was selected for Class 2500 (Bolt stress equals 52,500 psi).
3) Minimum stud length determined using ANSI B16.5, Appendix C Method for Calculating Bolt Lengths plus an additional half inch to accomdate the use of an insulation kit or SAE steel washers. For RTJ flanges an additional a half inch was added to the stud length to accomidate the ringed gasket.
4) Extra long studs are used for NPS 4 to NPS 12 to accommodate the preferred use of hydraulic tensioning; a 1.5x Stud Diameter was added to the minimum stud length (Lstud = Lmin + 1.5 x Dia.stud).

APPENDIX G TYPICAL STUD TIGHTENING SEQUENCE EXAMPLES



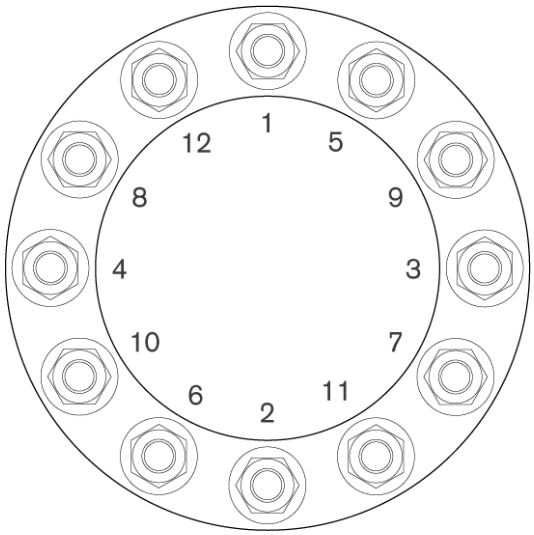






4 Stud Bolt Pattern

8 Stud Bolt Pattern



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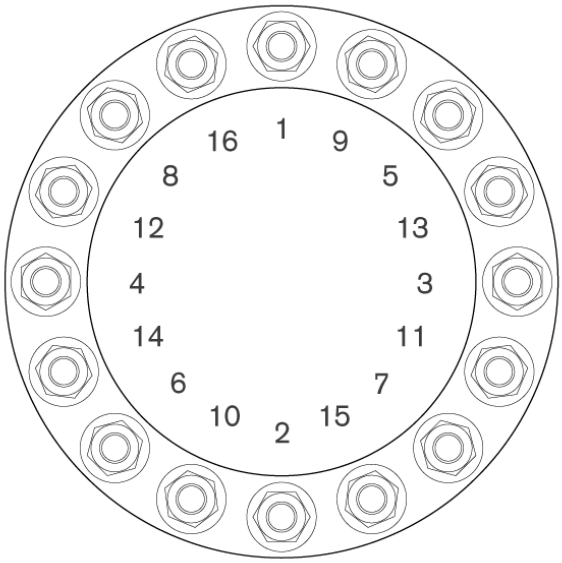

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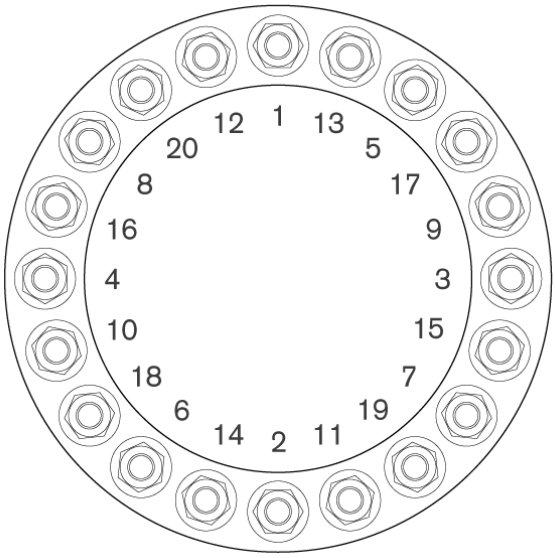
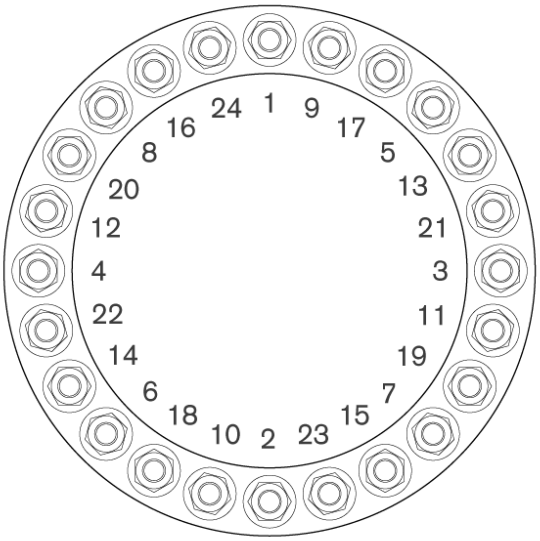
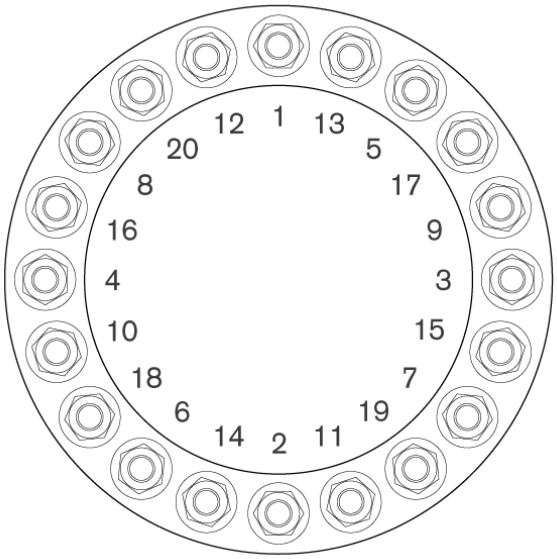
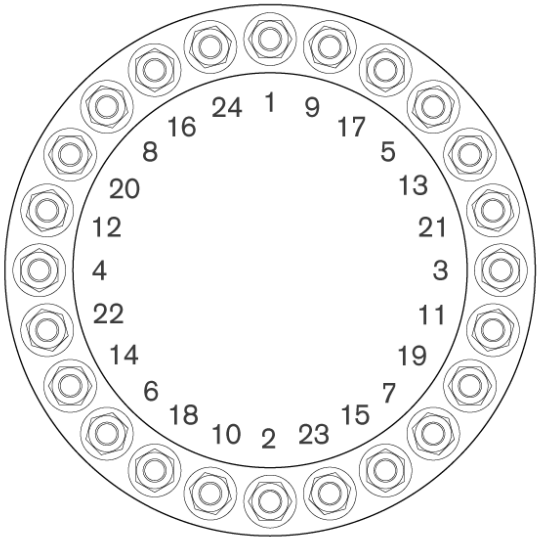


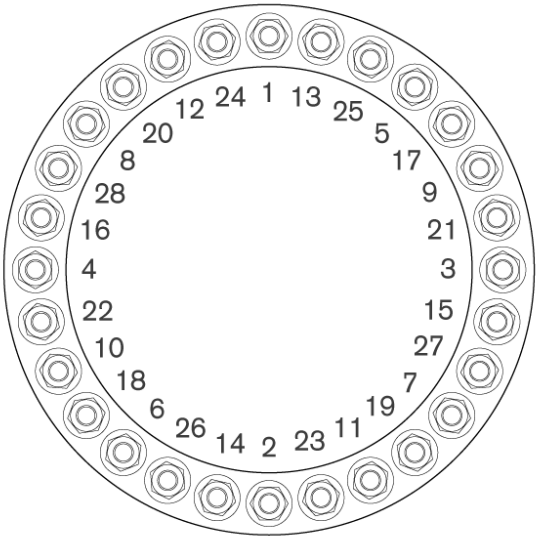


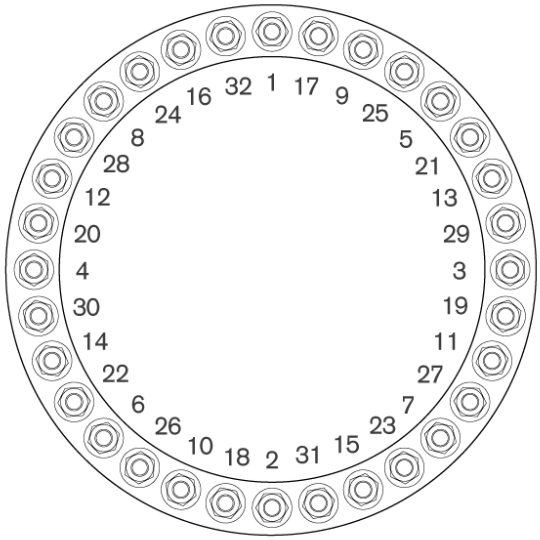


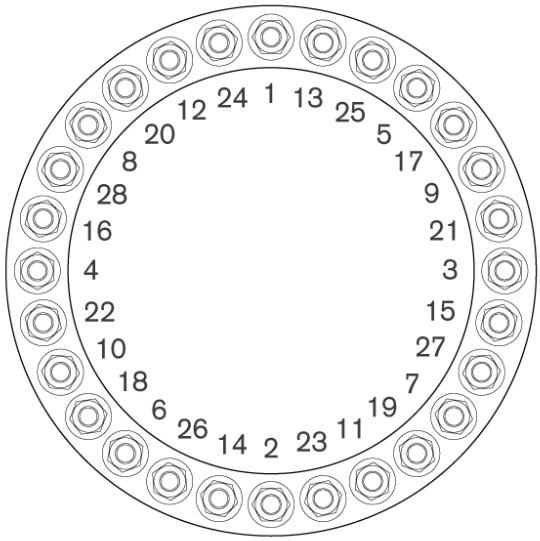


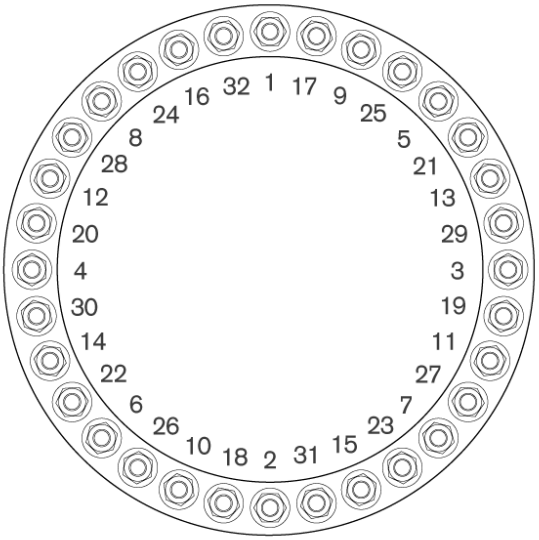
20 Stud Bolt Pattern

24 Stud Bolt Pattern







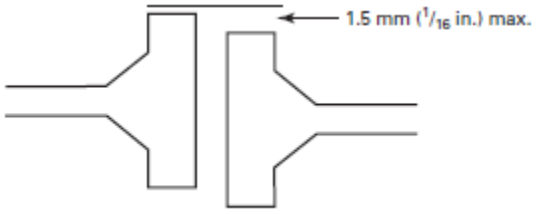
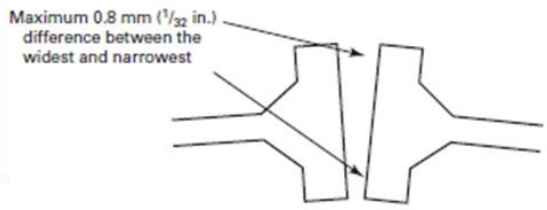
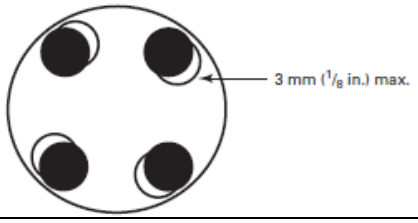
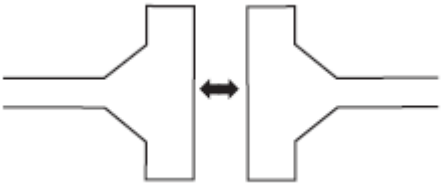


28 Stud Bolt Pattern

32 Stud Bolt Pattern

APPENDIX H FLANGE JOINT ALIGNMENT GUIDELINES

Table 9-1: Alignment Types[1]

Centerline high/low: the alignment of piping or vessel flanges so that the seating surfaces, the inside diameter of the bore, or the outside diameter of the flanges match or meet with the greatest amount of contact surface. Tolerance is usually measured by placing a straight edge on the outside diameter of one flange and extending it to or over the mating flange. This is done at four points around the flange, approximately 90 degrees from each other. The tolerance is 1.5 mm (1⁄16 in.) at any point.	
Parallelism: the alignment of piping or vessel flanges so that there are equal distances between the flange faces at all points around the circumference of the joint, therefore making the flange faces parallel to each other. The tolerance is usually determined by measuring the closest and farthest distance between the flanges and comparing. An acceptable practice is a difference no greater than 0.8 mm (1⁄32 in.) at the O.D. of the sealing surface, achieved using a force of no greater than 10% of the maximum torque or bolt load for any bolt.	
Rotational-two hole: the alignment of piping or vessel flanges so that the bolt holes align with each other, allowing the fasteners to pass through perpendicular to the flanges. The tolerance is measured by observing a 90-deg angle where the fastener passes through the flanges or the holes are within 3 mm (1⁄8 in.) of perfect alignment.	
Excessive spacing or gap: a condition where two flanges are separated by a distance greater than twice the thickness of the gasket when the flanges are at rest and the flanges will not come together using reasonable force. When no external alignment devices are used, the flanges should be brought into contact with the uncompressed gasket uniformly across the flange faces using less than the equivalent of 10% of the total target assembly bolt load. When aligning the flanges, no single bolt should be tightened above 20% of the single bolt maximum torque or target bolt load. When external alignment devices are used, the flanges should be brought to the compressed gasket thickness uniformly across the flange faces using an external load equivalent to less than 20% of the total target assembly bolt load. If more force is required to bring the flange gap into compliance, consult an engineer.	

[1] **As defined in Appendix E of ASME PCC-1-2013**

PURPOSE

This Specification applies to gas meter stations for non-sour service and defines design and stress analysis requirements.

The objectives of this Specification are to ensure:

1. The meter station is defendable to the code to which it was designed.
2. The Company's operating experience has been communicated through the requirements, recommendations, and preferences.
3. The piping systems maintain structural integrity and optimization through a given range of operating conditions within the meter station.

SCOPE/APPLICABILITY

This Specification applies to the following in all divisions of the Company and its wholly-owned subsidiaries, and all operated entities/facilities in Canada (CAN), United States (U.S.) and Mexico (MEX).

Unless otherwise specified, the Authenticating Engineer(s) is the subject for all the considerations and requirements included in this Specification.

The Authenticating Engineer(s) is also responsible for ensuring that the meter station is defendable to the code to which it was designed.

This Specification applies to all pipe diameters, grades, and wall thicknesses within a meter station for the following piping systems:

- High Pressure Gas System
- Power Gas System
- Gas Vent System (high pressure)
- Utility Fuel Gas System (high pressure)

Note: Even though a formal pipe stress analysis is only required for the High-pressure gas system, all the other piping systems that apply to this Specification have to follow the requirements listed in this specification. It is the Authenticating Engineer's responsibility to determine whether or not other piping systems require formal analysis.

This Specification does not apply to the following piping systems within a meter station yard:

- compressed instrument air system
- utility fuel gas system (low pressure)
- HVAC System
- drainage system

- potable water system
- gas vent system (low pressure)
- fire suppression system (non-hydro)

This Specification does not apply to tubing.

Within this Specification, TransCanada is referred to as the Company.

Within this Specification, the following terms and definitions apply for requirements:

- Shall—expresses a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard. Shall is not a recommendation but a requirement.
- Should—expresses a strong preference, recommendation or that which is advised, but not required.
- Must—denotes a requirement of the Company, for which no deviation or variance would be granted.
- May—expresses an option or that which is permissible within the limits of the standard.
- Consider—assumes that a competent person will evaluate options to fulfill the intent of the requirement and make a documented decision supported by evidence to ensure protection of people, equipment, and the environment by achieving the appropriate level of functional integrity.

Wherein the Manufacturer's literature, governmental or regulatory requirements conflict with this Specification, the more stringent requirement shall govern.

The long-term operability, reliability, and maintenance of the entire system shall be considered when deviating from the requirements and recommendations denoted as a "Should". The direction to deviate from the denoted "Should" statement is provided in a document Authenticated by the Company's Engineer(s) and approved by the Company's Project Manager describing the new requirements and recommendations.

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GLOSSARY

Boundary conditions

The set of conditions used for the behavior of the solution to the model or analysis at the boundary of its domain. Boundary conditions are important in determining the mathematical solutions to the physical problem.

Competent

Qualified, trained, and experienced to perform the required duties.

Concrete pad

A flat concrete pad that pipe rests on to limit pipe settlement. Concrete pads are typically located underground.

Demonstrate

The use of documentation in the form of records, measurements, tests, comparisons, experiments, or analysis by a competent person to verify or explain a decision.

Expansion loop

A loop in pipe, made up of 4 elbows or bends that provides enough flexibility to absorb thermal expansion and reduce temperature-induced pipe stress and displacement to an acceptable level.

Expansion jog

An off-set in pipe made up of 2 elbows or bends that provides enough flexibility to absorb thermal expansion and reduce temperature-induced pipe stress and displacement to an acceptable level.

Ethafoam® 220

A soft foam material used to mitigate elevated forces and stress concentration.

Flange clamp

A full encirclement clamp encompassing the entire circumference of the flange.

Flange grab

A flat plate with holes drilled to match a flange that provides an attachment point for structural bracing. The flange grab can be on the larger diameter piping, the small diameter piping, piping attachments or branch connections. Where possible, it is preferable to have the plate between the nuts and the flange.

Flexibility

A piping system designed with enough flexibility for thermal expansion, thermal contraction, or other movement without causing excessive stress in the piping, components or equipment.

Full encirclement clamp

A support that encompasses the full 360° of the pipe.

Foam

Three types of foam have been referenced within the pipe stress analysis section of this specification. Ethafoam® 220 is a soft material to mitigate elevated forces and stresses concentration. A high density polyurethane foam box is used to structurally reduce the backfill weight and reduce settlement on small diameter piping.

Gross Vehicle Weight Rating (GVWR), or Gross Vehicle Mass (GVM)

The maximum operating weight or mass of a vehicle as specified by the manufacturer including the vehicle's chassis, body, engine, engine fluids, fuel, accessories, driver, passengers and cargo, but excluding that of any trailers.

Isolation medium

A plastic or elastomer material placed between the pipe and the supports used to stop any steel-to-steel contact or fretting corrosion, as well as isolate the supports from the cathodic protection circuit.

Large diameter piping

Piping that is greater than NPS 6 in outside diameter.

Piping attachments

Attachments with a diameter up to and including NPS 6 attached to the large diameter pipe such as instruments and pressure taps.

Polyurethane foam box

High density foam used to structurally reduce the backfill weight and reduce settlement on small diameter piping.

Saddle support

A support that encompasses 120° to 180° of the pipe.

SIF

Stress Intensity Factor

Sleeper support

A flat pad or plate made of concrete or steel on which the pipe rests.

Small diameter piping

Piping with an outside diameter up to and including NPS 6.

Sliding medium

A material placed at the bottom of a support to reduce the load on the pipe by way of reducing friction.

Soil ratcheting

A phenomenon where the buried pipe displaces when loaded due to temperature or pressure. This leaves a gap around the elbow fitting or bend, which is filled in with soil particles, preventing the pipe from returning to its original position after unloading.

Temporary

A period of less than 6 months mainly used for piping and supports utilized for transportation, construction and/or operational requirements.

Ultra High Molecular Weight Polyethylene (UHMW)

A plastic that is highly resistant to corrosive chemicals, has an extremely low moisture absorption, a very low coefficient of friction and is highly resistant to abrasion.

1 STRESS ANALYSIS CONDITIONAL REQUIREMENTS

1.1 General Stress Analysis Requirements

1.1.1 A comprehensive or a simplified piping stress analysis shall be conducted for new meter stations or brownfield projects within the meter station.

Clarification: If it can be determined based on competent engineering judgment that modifications to the piping or pipe support(s) affect neither the stiffness of the support structure nor the flexibility of the piping, a comprehensive piping stress analysis may not be required, but a simplified analysis is still required.

1.1.2 A comprehensive piping stress analysis shall be conducted for any meter stations with a pressure drop that would cause an operating temperature below 0°C (32°F). For belowground piping, that includes the effects of frost heave.

Clarification: Flexibility issues and frost heave may occur in piping that is operating below 0°C. Special backfilling requirement may need to be applied.

1.2 Pipe Stress Analysis (Comprehensive)

1.2.1 A comprehensive pipe stress analysis shall be performed for the meter station if one of the following criteria is met:

- inlet and outlet yard piping is NPS 8 or greater
- contains one or more sour bottle(s)
- contains an off-skid inlet separator
- contains a hot tap installation with a branch connection NPS 4 and greater

1.3 Pipe Stress Analysis (Simplified)

1.3.1 A simplified pipe stress analysis shall be performed where a comprehensive stress analysis is not required.

1.3.2 The following shall be used to perform a simplified pipe stress analysis:

- hand/manual calculations
- formulas
- charts
- visual inspection
- competent engineering judgment

1.3.3 Simplified stress analyses shall be documented and supplied to the Project Manager.

1.3.4 Piping, equipment sizes, pipe supports and layout for the entire meter station shall be considered and reviewed to ensure that the pipe support requirements outlined in sections of this specification have been achieved and that any areas of pipe stress concerns have been addressed.

1.4 Units of Measure

1.4.1 International System of Units (SI) shall be used for pipe stress analyses on meter stations located within Canada and Mexico.

1.4.2 Imperial Units shall be used for pipe stress analyses on meter stations located within the United States.

2 GENERAL PIPE SUPPORTING REQUIREMENTS

2.1 Station Location Requirements

2.1.1 Underground piping within the facility should not be installed through deep organic soil types or continuous or discontinuous permafrost unless considerations have been given to specific design mitigations to prevent settlement or heaving of the piping.

2.1.2 For meter stations situated in organic soil types, or continuous or discontinuous permafrost types of terrain, the Company's Stress Engineering and Geotechnical Engineering personnel should be contacted for a complete review, unless the Project Engineer and Project Manager accept responsibility for the design and the installation of the piping through the complex soil conditions.

2.2 General Requirements for Locating Pipe Supports

2.2.1 Supports should not be located under reducers, elbows or horizontal tees unless structural stress discontinuities and their effect have been considered.

Clarification: Supports can be placed under flanges, and vertical tees directly under risers for blowdowns and pressure relief(s).

Clarification: Beam analysis may not accurately predict the stresses within a fitting combined with structural loading and may grossly underestimate the level of stress.

2.2.2 Pipe supports should not be placed under pressure vessel or tanks inlets, outlets and other nozzles without consideration of the additional loading on the nozzles.

2.2.3 Pipe supports should be placed under valve flanges and other flange joints where possible.

Clarification: Unless needed for operations or other design requirements, flange joints do not need to be added to facilitate a support at a particular location.

Clarification: It is understood that there is some reluctance to install a support under a flange joint. However, a support placed under the flange would increase natural frequency of the piping system by supporting the greater body of mass, particularly for valves. The support would reduce the forces transferred through the circumferential weld joint, reducing the probability of weld joint indications (flaws) propagating. The flange joint support will give the indication that excessive stress is being demanded from the pipe system.

2.2.4 Sour bottles shall be supported by saddles or clamps to control lateral displacement.

2.2.5 Specialized anchor flange fittings shall be used to facilitate aboveground pipe anchors or line stops.

Clarification: Flange joints cannot be used as a pipe anchor or a line stop because the extra loads may cause leaks.

2.2.6 NPS 12 or larger valves that have flanges (flange x flange or weld x flange), should be supported at the flange(s) to increase the natural frequency of the piping system.

Clarification: The mass of a valve or other assemblies supported from the attached piping will increase the contact stresses on the piping as well as the increased static stress within the adjacent weld. Combined with dynamic stresses, this may be excessive.

2.2.7 Heavy masses should not be supported by the adjoining piping unless the increased excessive contact stresses and weld joint stresses have been considered.

Clarification: The mass of the valves or other assemblies supported from the attached piping increases stresses on the piping, and therefore decreases the capacity of pipe to handle other operations loads.

2.2.8 Pipe supports shall be placed under the belowground piping where the piping transitions from belowground to aboveground to reduce excessive pipe settlement and deformation of aboveground piping.

Clarification: Excessive settlement of the belowground piping where the piping transitions from belowground to aboveground has caused excessive contact stress and flange fit-up issues. Accounting for settlement of underground flanges may not meet the flange leakage requirements.

2.2.9 The edge of the pipe support shall be designed to be a minimum of one pipe diameter (1D) away from any pipe girth weld.

Clarification: The one pipe diameter (1D) requirement does not apply to when a support is placed under a fitting (i.e., flange or a vertically-oriented tee).

2.2.10 For situations where the edge of the pipe support is less than a half of one pipe diameter (0.5D) away from any pipe girth weld due to design or construction errors, the support or girth weld shall be relocated.

2.2.11 For situations where the edge of the pipe support is less than one pipe diameter (1D) away from any pipe girth weld but greater than half of one pipe diameter (0.5D) due to design or construction errors, the support or girth weld should be relocated.

Consideration: If the edge of support is less than one pipe diameter (1D) but greater than half of one pipe diameter (0.5D) away from any pipe girth weld, a detailed Finite Element Analysis (FEA) of the shell may be required to ensure that the axial and shear membrane stresses applied to the piping by the pipe support and auxiliary loads do not influence the maximum allowable weld defects by code. The pipe girth weld should be ultrasonically inspected and all the linear indications removed.

Clarification: The shear distribution pattern is not well understood in the area extending one pipe diameter (1D) on each side of the support, which has been referred to as the *fuzzy zone* by some references. When combined with any residual weld stresses, indication (flaws) in the weld joint, there is a probability/risk that the indications (flaws) within the weld joint may propagate given these factors. Even if a fatigue analysis was conducted, it does not cover fracture initiation points or stress risers from weld flaws.

2.3 General Design Pipe Support Requirements

2.3.1 All pipe supports designed, constructed and installed shall be approved by the Company's Stress Engineering and Structural/Civil personnel unless the Project Engineer and Project Manager accepts responsibility for the design, installation and localized stresses caused by structural discontinuities.

2.3.2 All pipe supports shall be designed, constructed and installed to be removed and reinstalled with a minimum amount of difficulties and effort as possible.

Clarification: All pipe supports need to be removable from the piping and base for maintenance and integrity purposes.

2.3.3 Structural supports shall not be directly welded to any piping or pressure containing components including welding on dummy legs, saddles, supports or gussets.

Exception: Structural supports may be welded to pressure containing components where the structural supports were designed, fabricated and attached to the pressure containing components by the original equipment manufacturer.

Clarification: Welding a fillet weld to the pipe is problematic because: 1) it causes a concentrated discontinuous stress in the pipe, and 2) the fillet weld joint cannot be inspected by full volume inspection techniques.

2.3.4 Clearance for a longitudinal or spiral weld seam shall be by way of a gap in the isolation medium between all piping and the supports.

Clarification: The isolation medium for sleeper, saddle and full encirclement clamp supports needs to provide clearance for the longitudinal or spiral weld seam by way of a gap. Grinding off the longitudinal or spiral weld seam on the pipe to accommodate a support is prohibited.

2.3.5 A saddle type pipe support should be placed under the belowground piping where the piping transitions from belowground to aboveground for piping NPS 6 and greater unless the potential for excessive localized contact stresses have been considered.

Clarification: Excessive settlement of the belowground piping where the piping transitions from belowground to aboveground has caused excessive contact stresses on the underground piping when sleeper supports have been used.

2.3.6 Sleeper support or sandbag placed on undisturbed soil may be specified under the belowground piping where the piping transitions from belowground to aboveground for NPS 2 or NPS 4, instead of a saddle support, depending contact stresses within the pipe.

Clarification: Directly cradling or encasing the pipe with concrete as a support is not recommended due to maintenance and integrity concerns.

2.3.7 Clamp type pipe supports should not be used for underground piping unless excessive restraining of the piping has been considered.

2.3.8 All saddle and clamp type pipe supports with non-sliding bases should be bolted to the structure and not welded.

Clarification: The bolting of the pipe support base is preferred over the welding of the support due to removability for visual inspection. Bolting is also more affordable than welding.

2.3.9 All sliding saddle and clamp type pipe supports with lateral and/or axial sliding capability used for large diameter piping should be restrained in the vertical direction to the support foundation by bolts and slotted or rounded bolt holes.

Clarification: Pipe supports not attached to the pile cap or concrete foundation have been known to slide off the base. Therefore, this is to ensure that the support will not slide out from under the piping.

2.3.10 All sliding pipe supports that require lateral and/or axial sliding capability for small diameter piping should be restrained to the large diameter piping or the support foundation by bolting unless the increased natural frequency of the piping system and the potential for structural stress discontinuities have been considered.

2.3.11 Consideration should be given to the adjustability of the pipe support (through shimming or other means) to ensure that the pipe support maintains full contact with the piping.

2.3.12 Temporary supports and piping should be physically marked as *TEMPORARY* on the asset and the drawings.

Clarification: Temporary supports and piping may be required for transportation, construction and short-term operations requirements.

2.3.13 Temporary supports and piping needed for short-term operations shall meet the code requirements.

2.3.14 All bolted connections used on pipe supports should have screw threads that conform to *ANSI B1.1 - American National Standards Institute - Screw Thread Standards,* unless the extra operational complexity of another screw thread has been considered.

Clarification: Using a standard bolt thread reduces operational complexity.

2.3.15 All bolted connections should be lockable by lock nuts, double nuts, castle nuts, lock washers or cotter pins.

Clarification: Bolts need to be prevented from vibrating loose.

2.4 Isolation Medium

2.4.1 Isolation medium should be used between all piping and supports.

Clarification: Isolation material is also required to reduce vibrations and noise reverberating through the piping system, and to reduce the probability of magnifying the noise and allowing the noise to attenuate along the pipeline at a low frequency. Also, the purpose of the isolation medium between the piping and supports is to prevent any hard surface-to-surface contact or fretting that can damage the coating as well as isolation of the cathodic protection (CP) circuit.

2.4.2 Isolation medium may not be required between the anchor flange and the support.

Clarification: Isolation material might hamper the installation and function of the anchor flange and is not required unless required for isolation of the cathodic protection (CP) circuit.

2.4.3 Isolation medium should be designed with a gap to accommodate the weld seam unless consideration has been given to the effects of the contact pressure on the weld seam.

Clarification: The gap to accommodate the weld seam will reduce the contact pressure on the weld seam.

2.4.4 The design thickness of the isolation medium should be enough to prevent fit-up issues due to pipe seam welds for a saddle or a clamp support.

2.4.5 Isolation medium between all piping and supports should be any of the following, unless the long-term functionality during installation and operations of another material has been considered:

- Polytetrafluoroethylene (PTFE)/Teflon
- Ultra-High Molecular Weight Polyethylene (UHMW)
- Neoprene (Durometer Shore Hardness between A65 to A85)

2.4.6 Isolation medium should be designed and used with a minimum thickness of the following unless the long-term functionality during installation and operations of another minimum thickness has been considered:

- 3.0 mm (0.13 in.) for NPS 1-1/2 and smaller
- 6.0 mm (0.25 in.) for NPS 2 and greater

2.4.7 The radius of a saddle or clamp shall be designed with consideration of the thickness and compressibility of the isolation medium.

Note: Some off-the-shelf pipe clamp products are designed exactly to the nominal pipe outside diameter and cannot fit a layer of isolation medium.

2.4.8 U-bolts should be coated with neoprene rubber or a sheet of neoprene rubber, both with a thickness of 3 mm (0.125 in) or greater unless the functionality of another type of material and thickness has been considered.

2.4.9 U-bolt clamps should use a 6.0 mm (0.250 in) thick neoprene rubber on the bottom plate unless the functionality of another type of material and thickness has been considered.

2.5 Sliding Medium

2.5.1 Sliding medium should be used between all sliding surfaces of the support, unless the long-term functionality of another method has been considered.

2.5.2 Steel-to-steel or concrete-on-steel sliding surfaces should not be used, unless consideration has been given to determining the long-term functionality of the coefficient of friction, and determining the coefficient of friction experientially under multiple environmental conditions.

Clarification: The use of steel-to-steel or concrete-on-steel sliding surfaces has been found to be problematic during operations within the lifetime of the asset. The steel-to-steel surface rusts and forms a bond over a period. On the concrete-to-steel surface, the concrete has been found to crack or degrade over time. The increased friction has caused the neoprene to work its way out of the support causing coating damage and cathodic protection (CP) issues. It is recommended that the steel-to-steel or concrete-on-steel sliding surfaces be modelled with a range of friction coefficient, depending on the surface roughness expected over the life of the support.

2.5.3 Sliding medium required for sliding supports should be designed to encompass the entire base plate surface area of the sliding support.

Clarification: The longevity of small areas of sliding medium is dependent on the contact pressure. To increase the longevity, the surface area of the sliding medium needs to be maximized. The use of sliding medium with high contact pressures or thin sliding medium attached/bonded (glued) to steel plates has become a problem due to the wearing down of the sliding medium causing operational issues.

2.5.4 Sliding medium should not be pre-attached or bonded (glued) to thin steel plates or the support, unless consideration has been given to the degradation of the bond strength, the operability over time and the added cost.

Exception: Sliding medium pre-attached or bonded (glued) to washers or plates that cover slotted or rounded bolt holes due to the low contact pressures.

Clarification: The use of sliding medium pre-attached/bonded (glued) to thin steel plates, which are welded to the support, have caused problems with the welds cracking and the thin steel plates working themselves loose and sliding out from under the support.

2.5.5 Acceptable isolation medium for the base plate-sliding surface should be one of the following, unless consideration has been given to the long-term functionality of the coefficient of friction and determining the coefficient of friction experientially under multiple environmental conditions of another material such as:

- Teflon-to-Teflon
- Teflon-to-Steel

- UHMW-to-UHMW
- UHMW-to-Steel

Note: Ultra-High Molecular Weight polyethylene (UHMW)

2.5.6 Care should be taken to ensure that all belowground sliding supports are operational after backfilling.

2.5.7 The slotted bolt holes for the belowground sliding support should be filled with light foam or covered with oversized plate washers to prevent soil from entering and affecting the operability of the support.

2.5.8 The belowground sliding support should be protected by wrapping with foam and Denso tape to ensure operability, unless the long-term operability of other methods have been considered.

2.5.9 All belowground and aboveground sliding supports should be reviewed and approved by the Company's Stress Engineering and Structural/Civil personnel, unless the Project Engineer and Project Manager accepts responsibility for the support design, installation and long-term operability of the support.

3 DESIGN REQUIREMENTS FOR PIPE SUPPORTS CONFIGURATION

3.1 Saddles and Full Encirclement Clamps

Recommendation: Full encirclement clamp type pipe supports are recommended to reduce mechanical vibrations and reverberation, and to hinder potential noise attenuation along the piping. It is recommended to use full encirclement clamp type pipe supports in locations affected by mechanical vibration or with gas flow velocities greater than 21 m/s (68.8 ft/s) for an extended period of time.

3.1.1 The thickness of the steel full encirclement clamp or steel saddle utilized on the pipe should have a minimum thickness of the following, unless consideration has been given to the stiffness and function of a thinner clamp:

- 9.5 mm (0.375 in) for pipe sizes NPS 6 to NPS 12
- 12.7 mm (0.50 in) for pipe sizes NPS 16 to NPS 24
- 19 mm (0.75 in) for pipe sizes above NPS 24

Clarification: The thickness of the support is required to reduce the amount of shell flexibility in the piping.

3.1.2 The full encirclement clamp or steel saddle should have a minimum length along the axis of the pipe of the following, unless consideration has been given to the added local stresses, stiffnesses, and function of a saddle with a lesser width:

- 1/3 of one pipe diameter (0.33D) for pipe size greater than NPS 12
- 100.0 mm (4.000 in) for pipe size NPS 4 to NPS 12

Clarification: The length of the support is required to reduce the amount of rotation of the piping about the support.

3.1.3 A saddle support contact should be equal to or greater than 120° and less than or equal to 180°, unless the localized stresses caused by structural discontinuities have been considered for a saddle support with a different contact.

3.1.4 Full encirclement clamps should be used to contact or encompass at least 90% of the entire circumference of the pipe.

Clarification: The remaining 10% of the circumference allows for the gap in the clamp for tightening.

Note: There may be slight gaps between the pipe and the clamp which should be viewed as a concern with construction quality.

3.1.5 Full encirclement clamp supports and saddles should be fully removable by unbolting.

Clarification: The surface under the isolation medium/full encirclement clamps is an area that is susceptible to atmospheric corrosion because of the potential for aqueous environmental conditions between the isolation medium and the internal surfaces (pipe and/or clamp). Periodic visual inspection is required for maintenance and integrity purposes.

3.2 Point Contact Supports

3.2.1 Pipe supports with a single or multiple contact point(s) should not be used unless the possibility of an excessive contact pressure caused by structural discontinuities, known to cause dents, has been considered.

Clarification: Half-round circular type pipe supports that have a single or multiple contact point(s) have a very low capacity to support loads, due to the excessive contact pressure, and have been known to cause dents.

3.3 Linear Contact Supports

3.3.1 Pipe supports with a single linear contact (sleeper) or multiple linear contacts (double wedge) may be used as long as the supports meet the allowable criteria for membrane stress.

Clarification: Multiple linear contacts or a double wedge pipe support have two adjustable wedges on either side of the pipe.

3.3.2 Single linear contact type (sleeper) supports used belowground should have a minimum contact length of one pipe diameter (1D), unless the contact stresses and interaction between the stresses at the edge of the contact interacting with each other have been considered for a lesser contact length.

Clarification: With a narrow linear contact length, the stress concentrations on the pipe at the edge of the support will interact with each other, further reducing the capacity of the pipe to resist denting.

3.3.3 Multiple linear contact type supports should not be used to support belowground pipe, unless increased restraint and potential for increased contact stresses caused by structural discontinuities and the increased load on the pipe from the backfill have been considered.

3.3.4 Single (sleeper) or multiple linear contact type supports used aboveground should have a minimum contact length of half of one pipe diameter (0.5D), unless potential for increased contact stresses caused by structural discontinuities and interaction between the stresses concentration at the edge of the contact have been considered for a lesser contact length.

3.4 Flange Supports

3.4.1 A flange support may be a saddle or a beam under the flange joint.

3.4.2 Flange supports should not interfere with the bolting process or obstruct access to the flange bolts, unless the potential for obstructed access to the bolts has been considered in the design.

3.4.3 Flange supports should be a saddle when there is a concern for lateral displacement or vibration.

Clarification: The preference is to cradle the flange in a saddle, rather than having the flange sitting on a beam when there is a concern for lateral displacement or vibration.

Exception: It is acceptable to have the flange sitting on a beam for ultrasonic and orifice meters.

Clarification: Ultrasonic meters and orifice meters are supplied with anti-roll features and cannot be supported by a saddle. A beam-type support is required to support flanges with anti-roll features. Anti-roll features are required to transport meters for inspection and calibration.

3.5 Requirement for Flange Grabs Used for Bracing

Note: A flange grab is a steel plate that is bolted to the outside of the flange joint that can be used to provide support to the piping, where a flange clamp is a clamp that fully encircles the flange joint.

3.5.1 The weight of valves for NPS 12 or larger shall not be supported with a flange grab.

3.5.2 Pipe clamps and flange clamps utilized for bracing should be constructed from the following, unless consideration has been given to the stiffness effects of a thinner thickness:

- a minimum of 6.0 mm (0.25 in.) thick material for pipe sizes up to NPS 1-1/2
- a minimum of 9.5 mm (0.38 in.) thick material for pipe sizes from NPS 1-1/2 up to and including NPS 6
- a minimum of 12.7 mm (0.5 in.) thick material for pipe sizes greater than NPS 6

3.5.3 Flange grabs attached to the branch connection piping should be constructed from at least the following, unless the consideration has been given to the stiffness effects of a thinner thickness:

- a minimum of 12.0 mm (0.50 in.) thick plate for NPS 3/4 to NPS 6 branch connections
- a minimum of 19.0 mm (0.75 in.) thick plate for branches larger than NPS 6

Clarification: Due to the mass of some small diameter flanged-by-flanged valves, it is not uncommon to install a flange grab or support on both sides of the small diameter valves.

3.6 U-Bolt Clamps

3.6.1 U-bolts or U-bolt type clamps should not be used for piping greater than NPS 2, unless the increased rotational flexing of the piping system, decreased vibrational dampening capabilities, and the increased contact stress due to the structural discontinuities have been considered.

3.6.2 U-bolts or U-bolt type clamps shall not be used on large diameter piping to provide structural restraint bracing for small diameter piping, piping attachments and branch connections.

3.6.3 U-bolts used for clamping and supporting piping shall be kept to a minimum.

Clarification: Circumference pipe clamps are preferred over the use of U-bolts to stop rotational displacement, which pivots about the U-bolt support.

3.6.4 U-bolts shall be used in pairs with a minimum separation of one diameter (1D).

3.6.5 U-bolts shall not be used to support the weight of the pipe.

3.6.6 U-bolts shall not be over tightened.

Clarification: Overtightening is defined as the U-bolt cutting into the isolation medium (neoprene) causing the isolation medium to protrude between the piping and the U-bolt, leading to a loose fit and fretting damage.

3.7 Spring Supports

3.7.1 Spring supports or constant spring hangers should not be used for general support design unless the increased flexibility of the piping system, decreased natural frequency and the increased flexing of the pipe walls has been considered.

Exception: The exception is for the movement of piping due to the rotation of a tank nozzle caused by bulging and settlement in accordance with *API-650- Welded Tanks for Oil Storage*.

Note: Tanks are sometimes used in gas handling operations.

3.7.2 The use of any spring supports or constant spring hangers for piping should be reviewed and approved by the Company's Stress Engineering and Structural/Civil

personnel, unless the Project Engineer accepts responsibility for the design, sizing, installation, and utilization of spring supports or constant spring hangers.

3.8 Anchors/Line Stops

3.8.1 Aboveground pipe anchors or line stops should be attached to a specialized anchor flange fitting.

3.8.2 The use of anchors in the design should be avoided where possible.

3.8.3 Axial displacement of the pipe should be controlled by adding elbows to the piping system (i.e., expansion loops or jogs) to increase flexibility.

3.8.4 Aboveground pipe anchors or line stops shall not be attached to flange sets.

Clarification: A pipe anchor or line stop attached to flange sets may cause a leak or prevent the flange from meeting the flange leakage requirements.

3.8.5 Anchors or line stops shall not be welded, bolted, or attached to elbows, tees or piping.

Clarification: To reduce the risk from indications (flaws) within the fillet weld joints propagating through the weld joint or the piping, the weld joint should be inspected by full volume techniques. To facilitate a welded anchor or line stop, a fillet weld joint is required, which cannot be inspected by full volume techniques. The use of bolted anchors or line stops has been found to be problematic during operations within the lifetime of the asset (e.g., bolts coming loose, slippage of the anchor due to inadequate compressive loads for the anchor load, anchor loads being under estimated).

3.8.6 Belowground pipe anchors or line stops should not be used on piping without considering structural stiffness requirements and constructability issues to meet design requirements and operational inspection requirements.

Clarification: The structural requirements for a belowground pipe anchor would be the same as an aboveground pipe anchor or line stop.

3.8.7 Anchors or line stops should not be directly cradled or encased in concrete without considering operational inspection requirements.

Clarification: Cradling or encasing pipe does not meet maintenance and integrity requirements that pipe supports need to be removable for inspection.

3.8.8 The foundation design for an anchor shall consider the effects of soil creep if the foundation is not deep enough, using pilings.

3.9 Concrete Supports

3.9.1 A concrete pad may be used as a sleeper type support if the pad is in continuous contact with the pipe over a minimum of one pipe diameter (1D) of the pipe length.

3.9.2 Concrete supports should not directly cradle or encase the carrier pipe or any other pressure-containing components without considering operational inspection requirements, coating protection, and cathodic protection (CP).

Clarification: Pipe supports must be removable for inspection; cradling or encasing pipe does not meet maintenance or integrity requirements.

3.10 Soil Compaction

3.10.1 Compaction should be specified for all underground elbows, tees, hot taps and valves, especially at belowground and aboveground transitions to reduce the consequences if there is a lack of supporting soil.

3.10.2 Compaction should be specified on both sides of an installed underground support if over-excavation is expected, unless the potential for excessive contact stresses has been considered.

3.10.3 A written compaction plan or procedure shall be provided with reasonable expectations based on competent engineering judgment.

3.10.4 All of the following shall be provided on project-specific drawings:

- compaction area boundaries
- reference to the written compaction plan or procedure

Clarification: Relying on general backfilling specifications to define compaction control has been problematic in past construction projects. Defining the compaction objective and location in the drawings will reduce issues at time of construction.

3.10.5 Flowable fill may be used in isolated cases, if coating protection and cathodic protection (CP) have been considered.

3.10.6 Flowable fill shall not be within 152 mm (6 inches) from the bottom or side of the pipe.

3.10.7 Flowable fill shall not be within 304 mm (12 inches) from the top of the pipe and placed on well compacted backfill.

3.10.8 The Company's Stress Engineering and Structural/Civil personnel should review and approve the use of fillcrete/flowable fill as a pipe support, unless the Project Engineer accepts responsibility for the use of the fillcrete/flowable fill.

3.10.9 If fillcrete/flowable fill is to be used, a testing process, which includes mechanical material testing, should be developed to ensure the fill meets the intended requirements.

3.11 Supports Spacing for Aboveground Piping

3.11.1 Unless the effects of mechanical vibration, the natural frequency of the piping system (shell and beam modes), reduced susceptibility for vortex shedding and increased contact stresses have been considered, the allowable support spacing for aboveground piping should consider whichever of the following methods yields the shortest free span length:

1. The associated piping membrane stresses combined with the circumferential and longitudinal stresses do not exceed allowable stress limits.
2. The spacing equation:

$$Spacing(m) = 0.33 \cdot \sqrt{D(mm)} \qquad Spacing(ft) = 5.51 \cdot \sqrt{D(in)}$$

Where:

D = outside piping diameter

Reference: Kormann, P. and Zhou, J. June 25-28, 1995. *Support Spacing of Buried and Above-Ground Piping, Second International Conference, Advances in Underground Pipeline Engineering*. American Society of Civil Engineers, Bellevue, Washington.

3.11.2 The spacing may need to be reduced based on elbows, tees and heavy piping components.

3.11.3 The distance between supports should include the length of elbows, tees and other fittings, unless the influence of length of fittings on the natural frequency of the piping system and the increased stiffness has been considered.

Clarification: The objective is to increase the natural frequency high enough to avoid large amplitude response under any slight perturbing force.

3.11.4 Small diameter piping may be supported alongside steel I-beams or large diameter piping to reduce the number of single support foundations.

3.11.5 Terminating valves or blind flanges at the end of a continuous horizontal run of pipe should be supported at the valve or flange unless the increased flexibility of the piping system has been considered.

Clarification: Cantilevering a valve or flange off of the end of a pipe run will have a very low natural frequency and potentially cause cyclic fatigue under the right conditions.

3.11.6 Allowable distance piping cantilevered off of the end of a continuous run pipe should not exceed the values shown in Table 3-1.

Table 3-1: Cantilevered Spacing at the End of Continuous Piping for NPS 3/4 to NPS 2

Pipe Size	Maximum Span from Support (m)	Maximum Span from Support (ft.)
NPS 3/4	0.27	0.8 (9 inches)
NPS 1 to NPS 2	0.31	1.0 (1 foot)

3.12 Supporting Cantilevered Aboveground Small Diameter Piping Connections Requirements

3.12.1 Allowable support distance for aboveground small diameter piping cantilevered off the large diameter piping without a supporting restraint shall be used not to exceed:

$$Spacing(m) = 0.029 \cdot \sqrt{D(mm)} \qquad Spacing(ft) = 0.486 \cdot \sqrt{D(in)}$$

Where:

D = outside piping diameter

See Table 3-2 for cantilevered spacing calculated for NPS ¾ to NPS 6.

Table 3-2: Cantilevered Spacing Calculated for NPS ¾ to NPS 4

Pipe Size	Maximum Span from Support (m)	Maximum Span from Support (ft.)
NPS 3/4	0.12	0.42 (5.00 in.)
NPS 1	0.14	0.48 (5.50 in.)
NPS 1 1/2	0.18	0.59 (7.00 in.)
NPS 2	0.20	0.68 (8.00 in.)
NPS 3	0.25	0.84 (10.00 in.)
NPS 4	0.29	0.97 (11.00 in.)
NPS 6	0.30	1.00 (12.00 in.)

3.12.2 Piping cantilevered off the large diameter piping should be greater than NPS 3/4.

3.12.3 Valves, flanges, blind flanges, or other masses attached to large diameter piping should be designed to be fully supported, unless the reduction of the stress discontinuities at the base of the attachment has been considered.

Exception: Needle valves or tubing fittings cantilevered off the large diameter piping.

4 ACCEPTABLE STRESS MITIGATION METHODS REQUIREMENTS

4.1 Expansion Joint(s)

4.1.1 Expansion joint(s) should not be used on the piping systems that are covered by this Specification, unless consideration has been given to the long-term operating requirements.

4.2 Thermal Expansion Loops

4.2.1 Piping flexibility from thermal or other expansions should be provided using a piping offset using two elbows (i.e., expansion jog).

4.2.2 Aboveground and belowground vertical oriented expansion loops (consisting of four elbows) should not be utilized, without considering the reduced natural frequency of the piping system and access issues during operations.

Clarification: Vertically-oriented expansion loops are difficult to support following the support criteria of this Specification. Aboveground vertically oriented expansion loops have been known to have a very low natural frequency and could be a cause for cyclic fatigue due to wind.

4.2.3 Belowground horizontally oriented expansion loops (consisting of four elbows) should not be utilized without taking into consideration future site usage, space concerns, future excavation clearances, design requirements, additional welding, permanent soil displacements and soil voids.

Clarification: Over time, backfill will consolidate around the piping restricting displacement of the belowground horizontally-oriented expansion loop so in the long-term, the expansion loop does not function as designed.

4.2.4 Aboveground horizontally oriented expansion loops (U-bends) may be utilized for mitigation from thermal and seismic issues.

4.3 Void Form Expansion Medium

4.3.1 Expansion medium may be used to mitigate isolated areas of concentrated stress or displacement for belowground piping.

4.3.2 The acceptable expansion medium for mitigating isolated areas of concentrated stress due to thermal expansion of short sections of underground piping and fittings should be Ethafoam® 220.

4.3.3 Any other types of expansion medium shall be approved by the Company's Stress Engineering personnel or Project Engineer.

4.3.4 Expansion medium should be a sheet type.

4.3.5 Sheet type expansion medium should be punched with 13.0 mm (0.5 in.) holes at a maximum of 100.0 mm (4.0 in.) on centres lengthwise and widthwise for considerations of the permeability of the cathodic protection (CP).

4.3.6 Expansion medium should be designed to a maximum compressive deflection of 25% of the material thickness.

4.3.7 Expansion medium at risers should be designed to end aboveground and at the middle of the elbow belowground.

4.3.8 Expansion medium should not be used under the pipe, at the base of the pipe or wrapped around the pipe, unless the analysis can demonstrate that the extra settlement has been considered.

4.3.9 Spray-applied expansion medium should not be used, unless the long-term functionality and expansion of the material under uncontrolled environmental conditions has been considered and addressed.

Clarification: Spray-applied expansion medium applied under uncontrolled environmental conditions has been known to have issues for long-term reliability.

4.3.10 Expansion medium on elbows and other piping locations should not be used for aboveground piping, unless long-term degeneration due to environmental conditions has been considered.

4.3.11 Expansion medium should not be used on straight sections of underground piping for lengths greater than 5.0 m (16.4 ft).

Clarification: The expansion medium is most effective at bends and tees, but the effectiveness diminishes with distance from directional changes in the piping.

4.3.12 Expansion medium should not be used within an area where the pipe would be stressed by vehicular loading within a designated paved or gravel access road or laneway, unless the effect of the vehicular loading on the material has been considered.

5 SURFACE LOADING REQUIREMENTS

5.1 Vehicular Travel Crossing Requirements

5.1.1 Belowground pipe fittings should not be located within an area where the pipe would be stressed by vehicular loading greater than the Gross Vehicle Weight Rating (GVWR) of 4000 kg (9000 lbs), such as a paved or gravel access road or laneway.

Clarification: Heavy vehicles on a sustained vehicle crossing could cause prolonged and unaccounted stresses.

5.1.2 Belowground pipe fittings should be at least horizontally the same distance as the dimension for the design Depth of Cover (DoC) of the piping from a paved or gravel access road or laneway.

5.1.3 Piping crossings below a paved or gravel access road should be designed so that the angle between the centreline of the sustained vehicular travel surface being crossed and the centreline of the pipe is as close to 90° as possible, but not less than 75°.

5.1.4 Belowground piping that parallels a sustained vehicular paved or gravel access road should be designed with a separation from the edge of the travel surface to the edge of pipe greater than 7.0 m (23.0 ft).

Clarification: The 7.0 m (23.0 ft) allows for vehicles to travel off of the travel surface and space for maintenance and integrity purposes.

5.1.5 The crossings calculation for sustained vehicular travel and other types of vehicular travel surfaces should be conducted in accordance with *API 1102, American Petroleum Institute Steel Pipelines Crossing Railroads and Highways,* or *CEPA, Canadian Energy Pipeline Association Surface Loading Calculator.*

Clarification: The validation of pipe stress with other crossings method may be difficult to defend.

5.1.6 Belowground piping shall be designed to support the sustained maximum vehicular highway loads for the location.

5.1.7 Vehicular details for traffic loads greater than the maximum vehicular highway load for the location may be provided by the Project Manager, if greater vehicular traffic loads are expected.

Note: In some location, the wall thickness and grade for the underground piping may be governed by the stress caused by vehicular loading.

5.1.8 Pipe sections under a vehicular travel surface shall be calculated at both zero pressure and maximum pressure.

Clarification: Ring deflection calculations are required to ensure integrity for the unpressurized case.

6 PIPE STRESS ANALYSIS MODEL

6.1 General Requirements

6.1.1 Competent engineering judgment used for the analysis shall be documented in the Stress Analysis Report.

6.1.2 A comprehensive pipe stress analysis shall be conducted for the high-pressure gas system and documented in the Stress Analysis Report.

Clarification: Even though a comprehensive pipe stress analysis is only required for the High-pressure gas system, all the other piping systems that apply to this Specification have to follow the requirements listed in this Specification, including piping that falls under the simplified pipe stress analysis criteria. The requirement for a comprehensive piping stress analysis on the other piping systems should be based on competent engineering judgment.

6.1.3 The boundary conditions and all assumptions shall be based on competent engineering judgment and listed in the Stress Analysis Report.

6.1.4 If applicable to the analysis, all boundary conditions obtained from project documents such as the Design Basis Memorandum (DBM), and all assumptions shall be referenced.

6.1.5 The piping stress model shall include the meter station piping, pipeline tie-ins and assemblies, and adjoining pipeline up to the virtual anchor (VA) length.

6.1.6 Location factors separating pipelines, tie-ins, and meter station shall be clearly indicated in the drawings and the Stress Analysis Report.

6.1.7 The Company's Project Manager, with competent authenticated engineering justification, shall provide the following information:

- maximum operating temperature
- maximum design temperature
- minimum underground temperature
- minimum aboveground temperature
- maximum design pressure
- maximum licensed operating pressure

6.2 Pipe Analysis Software

6.2.1 Either of the following software products should be used for pipe stress modeling and analysis:

- AutoPIPE by Bentley Inc. (preferred)
- Caesar II by COADE Inc.

6.2.2 Alternative software for conducting stress analysis on meter stations should be code-compliant and approved by the Company's Stress Engineering personnel, unless the Project Manager accepts responsibility for the use of alternative software.

6.2.3 Specialty programs (FEA) should only be used in conjunction with programs that have code-checked integration, unless code-checking has been considered using another method.

6.2.4 All software files and models (original and convertible to AutoPIPE) should be supplied and attached to the hard copy of the report.

6.2.5 The Bourdon Effects or Calculated Pressure Extension for both translational and rotational displacements shall be accounted for in the analysis.

6.2.6 The Calculated Pressure Extension shall be accounted for in the analysis.

6.3 Restraint

6.3.1 Both aboveground and belowground piping shall be modeled and evaluated assuming unrestrained loading conditions, and that the pipe is able to move.

Clarification: The partial restraint from soil or pipe supports can be assumed to be unable to fully prevent movement of the piping.

6.4 Load Cases

Note: As part of the stress analysis and the Company's long-term commitment to performance, loading cases shall comply with both code compliance cases and the Company's loading requirements.

6.4.1 The operational case, cold case, and occasional case shall be analyzed.

6.4.2 The minimum and maximum temperatures defined in the Design Basis Memorandum (DBM) shall be used in the analysis.

6.5 Operational Case

6.5.1 The operational case shall include the following:

- effects of pressure (maximum operating pressure)
- operating temperatures (maximum operational temperature)
- pipe weight (including insulation, content, backfill overburden, underground pipe settlement and other externally imposed displacement such as nozzle displacements

6.6 Cold Case

6.6.1 The cold case shall be analyzed to determine whether the pipe stresses and loads on the pipe supports are within the allowable limits for cold case.

6.6.2 The cold case shall include the following:

- effects of pressure (maximum design pressure for all piping)
- operating temperatures (minimum temperature for all piping)
- pipe weight (including insulation, content, backfill overburden, underground pipe settlement and other externally imposed displacement such as nozzle displacements)

6.7 Occasional Case

6.7.1 The occasional case shall be analyzed to determine whether the piping system complies with the regulatory code for occasional stresses.

6.7.2 The occasional case shall include the operational case combined with the effect of external forces (wind and seismic).

6.7.3 Each occasional case shall be analyzed independently.

6.7.4 Wind - the building code (Canada, United States and Mexico) shall be used for the area where the meter station is to be located to determine the maximum wind speed (km/h for Canada and Mexico and mph for the United States) for a 50-year occurrence.

6.7.5 Wind - The predominant wind direction shall be used for the analysis.

6.7.6 Static Seismic (Earthquake) - The seismic loading shall be considered along with the operational case.

Clarification: A seismic event is most likely to occur while the piping system is in operation.

6.7.7 Static Seismic (Earthquake) - The seismic load shall be reported as Peak Gravity Acceleration (PGA), multiple in gravity acceleration equivalent (multiple of g-force).

Clarification: The seismic loading combined with the static load cases need to be combined to ensure code compliance.

6.8 Load Combinations and Allowable Stress Requirements

6.8.1 Bending stress from pressure elongation shall be accounted for in the analysis.

Clarification: The default AutoPIPE settings for CSA Z662 - *Oil and Gas Pipeline Systems*, tensile 2, may be missing the bending stress from pressure elongation. A custom code case may need to be added manually to ensure that the bending stress from pressure elongation is accounted for.

6.8.2 The code combinations for *American Society of Mechanical Engineers (ASME) B31.8 - Gas Transmission and Distribution Piping Systems* and *CSA Z662 - Oil and Gas Pipeline Systems,* provided in Table 6-1, shall be analyzed depending on facility location.

6.8.3 A bi-axial combined stress case shall be included in the analysis, in addition to any code requirements, considering all operational caseloads.

6.8.4 The bi-axial combined stress may be calculated using a Tresca or a Von Mises stress criterion.

6.8.5 Additional combinations should be added based on operating modes of piping systems. The code combinations provided are the base cases only.

6.8.6 All load case combinations shall be analyzed as presented in order of load sequence.

6.8.7 Local stresses caused by structural discontinuities and sites of local loadings combined with load case combinations should not exceed 0.9 of the Specified Minimum Yield Strength (SMYS).

Clarification: Often, local stresses are disregarded because the stresses are localized in influence, may be self-limiting, or relieved by local deformation. This includes stresses in branch connections caused by pressure or external loads, or stresses at structural discontinuities, as well as the contact stress caused by pipe supports. The codes do not fully address the maximum allowable value for local stresses or excessive stresses. However, not exceeding 0.9 of the Specified Minimum Yield Strength (SMYS) ensures that the design is defendable to the code.

Table 6-1: Code Combinations for ASME B31.8 and CSA Z662

Case No.	Load Combination	Stress Type	Description	Allowable
1	Max P	Hoop	Hoop stress ASME B31.8 Para. 841.1.1 CSA Z662, Clause 4.3.5.1	 SMYS x E x F x T SMYS x F x L x T
2	GR + Max P	Longitudinal	Stress due to Sustained Loads ASME B31.8 Para 833.6 CSA Z662, Clause 4.8.5	 0.75 x SMYS x T SMYS x F x L x T
3	Amb T to Max T	Longitudinal	Thermal stress range from restraint temp to the maximum temperature ASME B31.8, Para. 833.8 CSA Z662, Clause 4.8.4	 f[1.25(Sc+Sh)-SL] 0.72 x SMYS x T
4	Max Range (Max T to Min T)	Longitudinal	Thermal stress range from the minimum temp to the maximum temperature (refer to all combinations) ASME B31.8, Para. 833.8 CSA Z662, Clause 4.8.4	 f[1.25(Sc+Sh)-SL] 0.72 x SMYS x T
5	GR + Max P + U2	Longitudinal	Stress due to Sustained Load and Occasional (i.e.: Load earthquake, wind, and blowdown forces.) ASME B31.8, Para. 833.8 CSA Z662, Clause 4.8.5	 0.75 x SMYS x T SMYS x F x L x T
6	GR + Max P + Max T	Combined, Bi-axial	Combined Stress Without Bending Stress ASME B31.8, Para. 833.3 (a) CSA Z662, Clause 4.7.1	0.90 x SMYS x T 0.90 x SMYS x T
7	GR + Max P + Max T	Combined, Bi-axial	Combined Stress ASME B31.8, Para. 833.4 (c) CSA Z662, Clause 4.7.2.1	 0.90 x SMYS x T 1.0 x SMYS x T
8	GR + Max P + Max T + U1	Combined, Bi-axial	Combined Stress with Soil Settlement ASME B31.8, Para. 833.4 (c) CSA Z662, Clause 4.7.2.1	 0.90 x SMYS x T 1.0 x SMYS x T

Case No.	Load Combination	Stress Type	Description	Allowable
9	GR + Max P + Max T + U1 + U2	Combined, Bi-axial	Combined Stress with Soil Settlement and Occasional Load ASME B31.8, Para. 833.4 (c) CSA Z662, Clause 4.7.2.1	0.90 x SMYS x T 1.0 x SMYS x T

Table 6-2: Descriptions

Load	Description
GR	Weight of piping system due to gravity and soil overburden
Max P	Maximum operating pressure.
Max T	Maximum operating temperature. (may vary based on section of piping)
Min T	Minimum operating temperature. (may vary based on section of piping)
Amb T	Ambient temperature.
U1	Soil settlement
U2	Occasional loads (e.g., earthquake, wind, blowdown forces, etc.)
E	Weld joint factor
T	Temperature derating factor
F	Design factor
L	Location (Z662 only)
f	Fatigue factor
Sc	Defined in the codes
Sh	Defined in the codes
Sl	Defined in the codes
SMYS	Specified minimum yield strength

6.9 Content Weight

6.9.1 The content weight (i.e., density) shall be applied to all piping analyzed.

Clarification: Some models have assumed the contents of the pipe to be weightless; this weight (i.e., density) content may not affect the results of the model. However, this approach cannot be defended.

6.9.2 The content weight (i.e., density) shall be the value calculated at the maximum pressure.

6.10 Thermal Analysis Conditions

6.10.1 The maximum design temperature shall be defined as the highest temperature for the station (the maximum licensed operating temperature) as provided in the Design Basis Memorandum (DBM).

6.10.2 The minimum temperature for the underground portions of the pipe stress model shall be the lowest expected metal temperature at the time of restraint.

6.10.3 The minimum temperature for the underground portions of the pipe stress model should be as follows, unless an alternative definable minimum underground temperature has been provided:

- For Canada and the northern part of the United States, the minimum temperature for the underground portions of a piping system should be assumed -10°C (14°F), unless otherwise specified.
- For the southern part of the United States and Mexico, the minimum temperature for the underground portions of a piping system should be assumed +5°C (41°F), unless otherwise specified.

6.10.4 The minimum temperature for the aboveground portions of the pipe stress model shall be the lowest expected temperature for the region during operation.

6.10.5 The minimum temperature for the aboveground portions of the pipe stress model should be as follows, unless an alternative definable minimum temperature has been provided tracking environmental data for the past 50 years:

- For Canada and the northern part of the United States, the minimum temperature for the aboveground portions of a piping system should be assumed -45°C (-49°F), unless otherwise specified.
- For the southern part of the United States and Mexico, the minimum temperature for the aboveground portions of a piping system should be assumed -20°C (-4°F), unless otherwise specified.

6.10.6 The ambient/installation temperature shall be the lowest expected temperature for the region during construction:

- For buried piping the ambient/installation temperature should be the lowest expected ground consolidation temperature at the time of construction.
- For above ground piping the ambient/installation temperature should be the lowest expected air temperature at the time of construction.

6.10.7 The maximum temperature differential shall be the difference between the maximum operational temperature and the minimum temperature or the ambient/installation temperature, whichever is lower.

6.10.8 The maximum temperature differential shall be considered for the expansion case.

6.11 Soil Modelling Requirements

6.11.1 If a facility or project-specific soil analysis report is not available, all soil assumptions shall be based on competent engineering judgment and supplied in the Stress Analysis Report.

6.11.2 The soil constraints implemented in the pipe stress model shall be determined at the pipe depth of cover, soil properties and soil types typical for the area of construction.

6.11.3 Soil spring properties should be estimated using the methodology outlined in Appendix B of the *Guideline for the Design of Buried Steel Pipe – July 2001*, American Lifelines Alliance, unless justification can be given for the consideration of an alternative.

6.11.4 Soil spring properties determined from the stress analysis program, such as the *Underground Pipe Modeler*, *Buried Pipe Modeler*, or any other methodology used to determine the soil stiffness through use of the program, should be checked and evaluated by hand calculations, unless a consideration can be given why conducting hand calculations as a validation is not required.

Clarification: A plug-and-play type of approach to determining soil properties for underground piping analysis leads to over and underestimating the influences onto the piping. Without a good understanding of the *black box* the soil calculating programs cannot be used.

6.11.5 Overburden wedge weight shall be added as a uniform distributed load (to the computer model) to all underground piping, both new and existing.

6.11.6 The overburden compaction multiplier, defined in CAESAR II, shall not be used for stress analysis unless the following is provided:

- approval from the Company's Stress Engineering personnel
- the derivation of the overburden compaction multiplier
- a complete understanding of the interaction and influence the multiplier has on soil spring properties

6.12 Soil Settlement Modeling

6.12.1 Soil settlement displacement shall be applied to all new piping and newly excavated sections of existing underground piping.

6.12.2 Soil settlement displacement should not be applied to existing sections of piping that have not been excavated.

Clarification: The existing pipe is assumed to have already settled prior to being tied into the new piping.

6.12.3 A soil settlement displacement or void space under piping of 25.4 mm (1.0 in.) or greater should be applied to new and existing excavated sections of piping where there is a low probability of over-excavation and where compaction is being called for in the design.

Clarification 1: The amount of soil settlement is dependent on the soil properties, soil type and site conditions. The minimum settlement assumes that good construction practices have been followed and that strict compaction requirements have been achieved using competent compactable unfrozen backfill.

Clarification 2: Settlement of underground piping can occur even with the best procedures in place for the following reasons:

- Geotechnical analysis has determined that the elastic rebound from the removal of the soil to the ditch bottom causes an upward displacement of around 12.7 mm (0.5 in.), which causes settlement after backfilling and reconsolidation.
- Over-excavation of the ditch bottom to ensure proper pipe alignment and tie-ins will settle as the soil reconsolidates.
- Practical difficulties in achieving compaction under large diameter pipe, simply as a function of their size, can result in void space under large diameter pipe.

6.12.4 A soil settlement displacement greater than 25.4 mm (1.0 in.) should be applied to new and excavated existing sections of piping where there is a high probability of over-excavation, such as areas where pipe transitions between belowground and aboveground.

Clarification: Pipe settlement greater than 25.4 mm (1.0 in.) is a real possibility if the pipe is over-excavated. The amount of settlement is a site-specific issue and should be based on competent engineering judgment and supplied in the Stress Report.

Note: The individual(s) conducting the pipe stress analysis have a responsibility to understand the construction process, through discussions with the project team, to determine the locations where there is a low and/or high probability of over-excavation.

6.13 Pipe Support Design Loads

6.13.1 Support loads shall include, but are not limited to the following:

- soil settlement
- pipe weight
- overburden
- vehicle loads
- inspection tools
- blowdown pressure
- temperature
- hydro
- wind

6.13.2 The pipe support loads provided by the piping stress analysis should be unfactored for the Civil Designer.

Clarification: The appropriate factoring is to be determined by the Civil Designer based on the applicable design codes.

6.13.3 The maximum pipe support load should be divided into two load types: dead (gravity) load and live (all other loads).

6.13.4 Blowdown loads should be unfactored.

6.13.5 Soil overburden loads should be included as a dead load.

6.13.6 To validate the support type for both aboveground and belowground, localized membrane stresses shall be determined for unfactored support loads.

Clarification: With the pipe resting on a support, high localized stresses in both the circumferential and longitudinal directions are generated within the pipe wall adjacent to the edge of the support.

6.13.7 Localized pipe wall membrane stresses should be determined using Roark's Formulas.

Clarification: Allowing for a more detailed correlation of the localized membrane stresses through detailed Finite Element Analysis (FEA) is time consuming and resource intensive when an analytical solution is just as effective.

Recommendation: Determine the maximum allowable support load for each support type, pipe size, wall thickness and grade at the initial stage of the project to ensure that the loads are not exceeded, and tabulate the allowable loads in the report.

6.13.8 Alternative methods for determining localized membrane stresses require pre-approval from the Company's stress engineering personnel or the Project Engineer and Project Manager.

6.13.9 Localized pipe wall membrane stresses shall be combined with the circumferential and longitudinal stresses to ensure that the allowable stress requirements are not exceeded.

Clarification: Determination of localized pipe wall membrane stresses combined with the circumferential and longitudinal stresses is a very important calculation and will be a focus in the *Initial Procedural Document*.

6.13.10 Beneficial effects gained from restraining soil that reduces localized membrane stresses should be ignored in the calculation.

6.13.11 The stiffnesses of the supports in the vertical, lateral and axial directions used in the piping stress analysis should be estimated based on competent engineering judgment.

Recommendation: Predetermine the approximate stiffness of a support type or structural assembly, within an order of magnitude, by a structural engineer. The point

of determining the support stiffness is to have an idea of the structural rigidity of the support and to attain realistic loads.

6.14 Pipe Support Coefficient of Friction

6.14.1 The coefficient of friction should not be lower than the following minimum requirements, unless consideration has been given to the long-term functionality of the coefficient of friction, and determining the coefficient of friction experientially under multiple environmental conditions as per Table 6-3.

Table 6-3: Pipe Support Coefficient of Friction

Conditions	Minimum Coefficient of Friction
UHMW-to-UHMW (Ultra-High Molecular Weight polyethylene)	0.2
UHMW-to-Steel (steel is coated or painted pipe)	0.2
Neoprene-to-Steel (steel is coated or painted pipe)	0.4
Steel-to-Steel (steel is coated or painted support to steel of coated or painted pipe)	0.4 to 0.8 (check both cases as a minimum)
Concrete-to-Steel (concrete support to steel of coated or painted pipe)	0.4 to 0.8 (check both cases as a minimum)

Recommendation: The use of steel-to-steel (i.e., support-to-pipe) and concrete-to-steel (i.e., support-to-pipe) contact is not recommended. Interfacial corrosion and adhesion would make the coefficient of friction unpredictable and the long-term environmentally exposed interface would be unreliable.

6.14.2 If steel-to-steel (i.e., support-to-pipe) and concrete-to-steel (i.e., support-to-pipe) surface contact are to be used, two extreme cases should be investigated: 1) the lower friction case of 0.4 to 0.8 and 2) a higher friction case greater than 1.2.

Clarification: If there is a chance that the support could seize and due to rust, corrosion, or surface roughness conducting the analysis over the range will help determine the risk to the piping system.

6.14.3 The coefficient of friction for steel-to-steel (i.e., support-to-pipe) and concrete-to-steel (i.e., support-to-pipe) contact should be tested under environmental conditions and surface roughness expected over the life of the support to ensure that the analysis is defendable.

6.15 Allowable Pipe Support Displacement

6.15.1 The Company's Engineering personnel should be contacted for guidance, if the piping displacements determined from the initial layout and analysis are outside of the recommended displacements.

6.15.2 The maximum piping displacement at the location of aboveground pipe support should not exceed the absolute value of the following, unless consideration has been

given to the long-term functionality of the support, regulatory compliance concerns, maintenance and operational concerns as per Table 6-4.

Table 6-4: Allowable Pipe Support Displacement at Aboveground Pipe Support

Direction	Maximum Pipe Displacement
Axial direction	63.5 mm (2.50 in.)
Lateral direction (sliding support)	25.4 mm (1.00 in.)
Lateral direction (non-sliding support)	6.0 mm (0.25 in.)
Vertical upward direction	4.0 mm (0.15 in.)
Vertical upward direction (blowdowns and valves)	3.0 mm (0.12 in.)
Vertical upward direction (first support from riser)	12.0 mm (0.47 in.)
Vertical downward direction	6.0 mm (0.25 in.)

Clarification: The first support aboveground, after the riser, may receive vertical lift due to thermal displacement. Care needs to be taken to ensure that piping is not over stressed and the support is functional for the operational range.

6.15.3 The maximum piping displacement at the location of belowground pipe support should not exceed the absolute value of the following, unless consideration has been given to the long-term functionality of the support, and soil ratcheting as per Table 6-5.

Table 6-5: Allowable Pipe Support Displacement at Belowground Pipe Support

Direction	Maximum Pipe Displacement
Axial direction	63.5 mm (2.50 in.)
Lateral direction (sliding support)	25.4 mm (1.00 in.)
Lateral direction (non-sliding support)	6.0 mm (0.25 in.)
Vertical upward direction	4.0 mm (0.15 in.)
Vertical downward direction	6.0 mm (0.25 in.)

6.15.4 Facilities to pipeline tie-in should be located where the displacement is at a minimum or where additional piping flexibility has been added to minimize displacement, unless consideration has been given to the long-term functionality of the support and the increased engineering vigilance on the structural requirements.

6.15.5 Blowdowns should be located where the thermal movement from the attached piping is at a minimum, unless consideration has been given to the long-term functionality of the support and the increased engineering vigilance on the structural requirements and increased costs.

Clarification: The blowdown needs to be seated on the pipe supports to ensure that the thrust loads during blowdown operation are taken by the supports.

6.16 Fittings

6.16.1 Fittings should be modeled as pipe, unless the stresses of the fittings exceed the allowable code stresses.

6.16.2 The wall thickness of fittings NPS 16 and greater may be increased up to 1.4 times the nominal pipe wall thickness for tees and 1.2 times the nominal pipe wall thickness for elbows, once approved by the Project Manager.

6.16.3 Elbow and tee fittings smaller than NPS 16 shall be modeled with the same wall thickness as the adjoining pipe.

6.16.4 The assumption of increasing the wall thickness of the fitting in the analysis shall be documented in the Stress Analysis Report and validated through the procurement process.

6.16.5 The assumption of increasing the wall thickness of the fitting in the analysis shall be approved by the Company's Stress and Mechanical Engineering personnel or the Project Engineer and Project Manager.

6.16.6 For each type of fitting used, the Stress Intensity Factors (SIFs) shall be documented along with the assumption for that fitting.

6.16.7 The SIFs provided in *CSA Z662 - Oil and Gas Pipeline Systems, Gas Transmission and Distribution Piping Systems* or *ASME B31.8 - Gas Transmission and Distribution Piping Systems* shall be used unless approved by the Company's Stress and Mechanical Engineering personnel or the Project Engineer and Project Manager.

6.17 Flange Analysis

6.17.1 Flange Analysis shall be conducted for all large diameter piping.

6.17.2 *ASME Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 1, Rules for Construction of Pressure Vessels - Appendix 2, Rules for Bolted Flange Connections with Ring Type Gaskets* shall be used for conducting the flange analysis.

6.17.3 The calculated or determined externally induced forces and moments shall be included in all flange analyses conducted.

Clarification: The flange analysis is a very important calculation and will be a focus in the *Initial Procedural Document*.

6.17.4 Flanges not meeting the flange analysis criteria of *ASME BPVC-VIII, Division 1, Appendix 2* after reasonable efforts have been made to mitigate by relocation, piping re-design and/or rating increase, may consider *ASME BPVC-VIII, Division 2, Section 4.16 - Design Rules for Flanged Joints,* including the calculated or determined externally induced forces and moments.

6.17.5 Written approval from the Company's Stress Engineering personnel, Mechanical Engineering personnel, Project Engineer and Project Manager shall be obtained before using *ASME BPVC-VIII, Division 2, Section 4.16* as a flange analysis criteria.

6.17.6 Alternative methodologies for conducting flange analysis should not be considered.

Note: The direct design requirement to conduct a flange analysis may not be specifically listed in the piping design code as a design requirement. However, inspecting, identifying, monitoring, tracking, preventing and eliminating fugitive emissions or leaks are regulatory and legal requirements, and are essential to ensuring the Company's commitment to the environment. In part, flange connections have been identified as a source for fugitive emissions that require continuous annually monitoring and, in certain jurisdictions, prompt repair or mitigation. Therefore, increased engineering vigilance to ensure that the flange joint meets the flange analysis requirements for the location reduces the probability of the flange joint being an integrity concern.

6.18 Discontinuity Stresses

6.18.1 Protection shall be provided against membrane stresses, ratcheting and fatigue failure for discontinuity conditions using sound engineering judgment and practices.

6.19 Mitigation for Stress Issues

6.19.1 Expansion medium may be used for underground piping to mitigate stress concentrations issues, soil ratcheting, and displacement concerns.

6.19.2 Expansion medium (i.e., Ethafoam® 220) may be modeled by any of the following methods:

- applying a stiffness coefficient for the expansion medium
- removing the soil stiffness coefficient, leaving a void for the area where expansion medium is planned

6.19.3 Flanges that do not meet the flange leakage criteria should be relocated and reevaluated.

6.19.4 Flanges not meeting the flange analysis criteria after being relocated and reevaluated may be upgraded or removed with the approval of the Company's Stress Engineering personnel, Mechanical Engineering personnel, Project Engineer and the Project Manager.

6.19.5 If the pipe displacement at the location of a pipe support is greater than allowed the following methods may be applied:

- the pipe support relocated and reevaluated
- flexibility added to the piping
- adjusting and modifying the pipe support

6.20 Evaluation of Existing Piping Impacted by New Piping or Piping Modifications

6.20.1 A model of the original un-modified piping should be developed.

6.20.2 The stress on existing piping shall be checked to meet the code of compliance.

6.20.3 Any areas on existing piping not meeting current analysis or current code of compliance shall be documented.

6.20.4 The Company's Project Manager and Pipe Stress Analyst shall ensure that the modifications do not cause detrimental stress increases to the existing piping.

6.20.5 If the original piping exceeds the current code of compliance, the original piping shall be evaluated against the code of compliance at the time of design.

6.20.6 A structural pipe support evaluation shall be conducted if there is a significant increase in the support loads.

6.20.7 The equipment nozzles shall be evaluated against allowable load.

7 DOCUMENTATION AND REPORT REQUIREMENTS

7.1 Analyst and Experience Requirements

7.1.1 Pipe stress analysts require a bachelor's degree in mechanical or civil engineering, followed by a minimum of five years of project training in a piping department responsible for design, while under the supervision of senior/or principal pipe stress engineers.

7.1.2 Pipe stress analysts with less formal education shall have 10-15 years of practice and supervision to be responsible for the design (i.e., pipe stress analysis).

7.1.3 The names of the individual(s) conducting the pipe stress analysis shall be listed in the *Initial Procedural Document* and the reports.

7.1.4 The experience of the competent individual(s) with demonstrated understanding and experience in the application of pipe stress analysis shall be listed.

7.2 Initial Procedural Requirements

7.2.1 Competency of the individual(s) conducting the stress analysis and the individual(s) checking their work shall be demonstrated and documented at the initial stage of the project.

7.2.2 The Project Engineer or Project Manager should provide a list of Company-approved support types at the kick-off meeting.

7.2.3 An *Initial Procedural Document* shall be provided to the Company during vendor qualification and updated whenever a stress analysis is being conducted as part of the project.

7.2.4 A written *Initial Procedural Document* describing the method for conducting the stress analysis piping shall be completed prior to engineering analysis being conducted.

7.2.5 The written *Initial Procedural Document* shall include the following:

- general information – listing (purpose, method, assumptions, supplemental calculations, references, analysis theories, etc.)
- quality control procedure which describes the process of reviewing, checking and authenticating the stress analysis report, analysis and calculations

Clarification: A common problem is the lack of communication and understanding of the analysis to be conducted and the procedural approach that will be followed during the engineering analysis. This includes the documentation required to ensure the analysis was conducted methodically, and reviewed, checked and authenticated by competent individual(s) having experience to demonstrate understanding in the application of stress analysis.

7.2.6 The written *Initial Procedural Document* for this Specification shall also include, at a minimum, the methodology for calculating the following:

- pressure and temperature assumptions
- pipe weight with the added operational contents weight
- list of piping systems to be modeled
- method for applying overburden loads
- soil spring properties and methodology
- extent of the piping to be modeled, including existing piping
- soil settlement modeling methodology
- load cases to be run in the model
- outline of any supplemental calculations or modeling being done that is unique to the project
- list of the pipe support types that are going to be used for the project aboveground and belowground with corresponding support stiffness
- method for determining localized membrane stresses

7.2.7 The written *Initial Procedural Document* procedure shall be reviewed, checked, authenticated and delivered to the Project Manager for review by the Company's Engineering personnel.

7.2.8 The written *Initial Procedural Document* procedure and approach should be reviewed to ensure it meets the Company's minimum requirements and is based on solid engineering judgment before engineering analysis is conducted.

7.2.9 Any changes and comments made by the Company to the written procedures and approach should be implemented before engineering analysis is conducted.

7.3 Stress Analysis Report Requirements

7.3.1 A Stress Analysis Report shall be provided if a comprehensive piping stress analysis is being conducted as part of a project within a meter station yard.

7.3.2 A comprehensive piping stress analysis report shall include, but not be limited to, the following:

1. General Information

- brief description of the project
- software used for creating the model
- piping code used
- maximum allowable pipe stress
- equipment loads
- sketch or drawing with dimensions used to create the model

2. Pipe Support Table
   - support name (tag#)
   - point number
   - location (aboveground/belowground)
   - depth of cover
   - pipe sizes wall thickness
   - material grade support type
   - support description
   - isolation medium between pipe and support
   - gap up, left, and right
   - support stiffness
   - loading direction
   - maximum loads (lateral, vertical, axial)
   - dead load
   - soil load
   - live load
   - pipe displacements (lateral, vertical, axial)
3. Assumed Operating Conditions
   - load cases
   - maximum pipe temperature
   - ambient temperature
   - soil temperature
   - minimum pipe temperature pressures
4. Assumed External Loads
   - soil overburden
   - soil properties
   - depths of soil cover
   - estimated soil spring properties

- soil settlement (areas of model affected)
- vehicle loads (areas of model affected)
- sustained forces (weight of pipe, components, contents (hydro) insulations cover, wind loading)

5. Images
   - stress magnitude spectrum in piping
   - location of nodes in stress model
   - locations of supports and support types
   - the distance of pipe support from reference points such as centreline of elbows, tees, etc.
   - locations of installed stress mitigation methods (e.g., Ethafoam® 220)
6. Areas of Concern
   - table of pipe stress ratios/values at nodes
   - table of support loads referencing a labelled picture for support location
   - changes made to piping arrangement to reduce stresses, if any
   - any stress mitigation methods and estimated stiffness (e.g., Ethafoam® 220) including a list of the physical properties and test methods
   - recommendations/discussion.
7. Calculations
   - wall thickness calculation or reference
   - SIF (show calculation if different than code SIFs)
   - soil overburden load calculations
   - Virtual Anchor (VA) length calculations
   - soil spring calculations
   - membrane stress calculations for pipe sizes, wall thicknesses, grades and support types
   - blowdowns and pressure relief valves force calculations
   - flanges leakage calculations
   - vehicle loading calculations
8. Procedures
   - written compaction plan or procedure
9. Discussion
   - issues and limitations of the designed system including: explanations, examples, sketches, and illustrations
10. Analyst and Experience

- The names of the individual(s) conducting the pipe stress analysis shall be listed.
- The experience of the competent individual(s) with demonstrated understanding and experience in the application of pipe stress analysis shall be listed.

7.3.3 The report shall be issued to the Project Manager.

7.3.4 The draft report should be issued before drawings are issued for review (IFR).

7.3.5 The final report shall be issued before drawings are issued for construction (IFC).

8 VARIANCES

Any deviation shall follow the TransCanada Management of Change (MOC) Variance Procedure. External vendors must contact the TransCanada Project Engineer for variance approval.

9 ROLES AND RESPONSIBILITIES

Table 9-1 below outlines the roles and responsibilities required for the use of this Specification.

Table 9-1: Roles and Responsibilities

Role	Responsibilities
Civil Designer	The Civil Designer is responsible for ensuring: • completion of the civil design • calculation of support stiffness • provision of calculations to the Pipe Stress Analyst • incorporation of the support loads (as determined by the stress analysis) into the design of the pipe supports
Checker, Civil Designer	The Checker is responsible for ensuring that the Civil Designer(s) has: • completed the civil design • calculated the support stiffness • provided calculations to the Pipe Stress Analyst • incorporated the support loads (as determined by the stress analysis) into the design of the pipe supports