| Rev. | | |
|---|---|---|
| | The following parties are to refer to this newly created Specification:<br>• U.S. pipeline and facility projects<br>• Mexico pipeline and facility projects<br>This Specification requires that Company individuals involved in pressure testing activities complete classroom pressure testing training.<br>Natural Gas is permitted as a test medium with safety test plan and Company approval.<br>Temporary test head assemblies are included to support project needs. | Vivian Liu |

## 16 DESCRIPTION OF CHANGE

| Section | Description of Change |
|---|---|
| **Regulatory** | |
| NOM-007-SECRE-2010 | New requirements to be considered |
| **Industry Standards** | |
| N/A | N/A |
| **General** | |
| • Aligned Specification to common U.S. terminology.<br>• Separated gas and liquid pressure testing requirements where possible<br>• Clarified pressure testing roles. Align roles and responsibilities with U.S. and Mexico organizational structure.<br>• Allowed the project to use temporary test head assemblies.<br>• Added service line and plastic line pressure testing requirements.<br>• Added pressure testing requirements for auxiliary piping and tubing.<br>• Added non-pressure tested field welds justifications. | |

## 17 APPROVALS

| APPROVALS | | |
|---|---|---|
| Originator:<br>David Scalzo, P. Eng.<br>Design Services – FIDE | Signature | April, 25, 2017<br>Date |
| Reviewer:<br>Masroor Husain, P.Eng.<br>Design Services – FIDE | Signature | APRIL 25, 2017<br>Date |
| Reviewer:<br>Gerard Lalonde, P.Eng.<br>Design Services – FIDE | Signature | 4/25/2017<br>Date |
| Reviewer:<br>Dawood Habib, P.Eng.<br>Design Services – FIDE | Signature | 4/25/2017<br>Date |
| Reviewer:<br>Gary Hawthorne<br>US Project Engineering | Signature | 4/25/2017<br>Date |
| Reviewer:<br>David Anderson<br>US Regulatory Compliance | Signature | 4/26/17<br>Date |
| Reviewer:<br>Lee Romack<br>Manager, US Regulatory Compliance | Signature | 4-28-2017<br>Date |
| Reviewer:<br>Eric House<br>US Project Engineering | Signature | 4/26/2017<br>Date |
| Reviewer:<br>Sandy Robinson<br>US Project System Maintenance & Implementation | Signature | Date<br>2017 APR 24<br>Date |
| Reviewer:<br>Gustavo Marcelo Guaytima<br>MEX Quality & Internal Compliance | Signature | MARCH 27th 2017<br>Date |
| Reviewer:<br>Jason Lopez<br>US & MEX Construction Management Services | Signature | 2017/04/26<br>Date |
| Reviewer:<br>Stan Parrish,<br>US Principal Engineer ,Integrity Eng. Services East | Signature | 4/27/17<br>Date |
| Reviewer:<br>Paul Shaffer<br>US Construction Compliance Manager | Signature | 4/26/2017<br>Date |
| Responsible Engineer:<br>Vivian Liu, P. Eng.<br>Design Services – FIDE | Signature<br>May 03, 2017<br>Date | PROFESSIONAL ENGINEER ALBERTA VIVIAN LIU<br>APEGA Permit to Practice P7100 |
| Management Endorsement:<br>Riaz Muhammad, Manager<br>Design Services – FIDE | Signature | MAY 4, 2017<br>Date |

# APPENDIX A (NON-MANDATORY) – EXAMPLES OF NON-PRESSURE TESTED WELD LOCATIONS OF PIPELINE ASSEMBLIES

## A-1 SIDE VALVE INSTALLATION

### A-1-1 BY HOT TAP

When a new side valve assembly is required on an existing pipeline using a hot tap there will be one non-pressure tested weld to connect the valve assembly pipe to the stub, which has been previously welded to the pipeline.

**Rationale:**

The only weld that is required is the weld between the prefabricated valve assembly and the stub on the existing pipeline. The weld completed to attach the stub to the mainline and the structural welds completed on the reinforcement saddles cannot be safely pressure tested due to the hydrostatic pressure that would be applied to the external surface of the run pipe.

**Note:**

The weld count does not include branch connection welds (buttering weld layers, run pipe to stub grove/fillet weld), or any reinforcement fitting to pipe welds which are considered intrinsic to the reinforcement and hot-tapping process.

### A-1-2 BY INSTALLATION OF A TEE

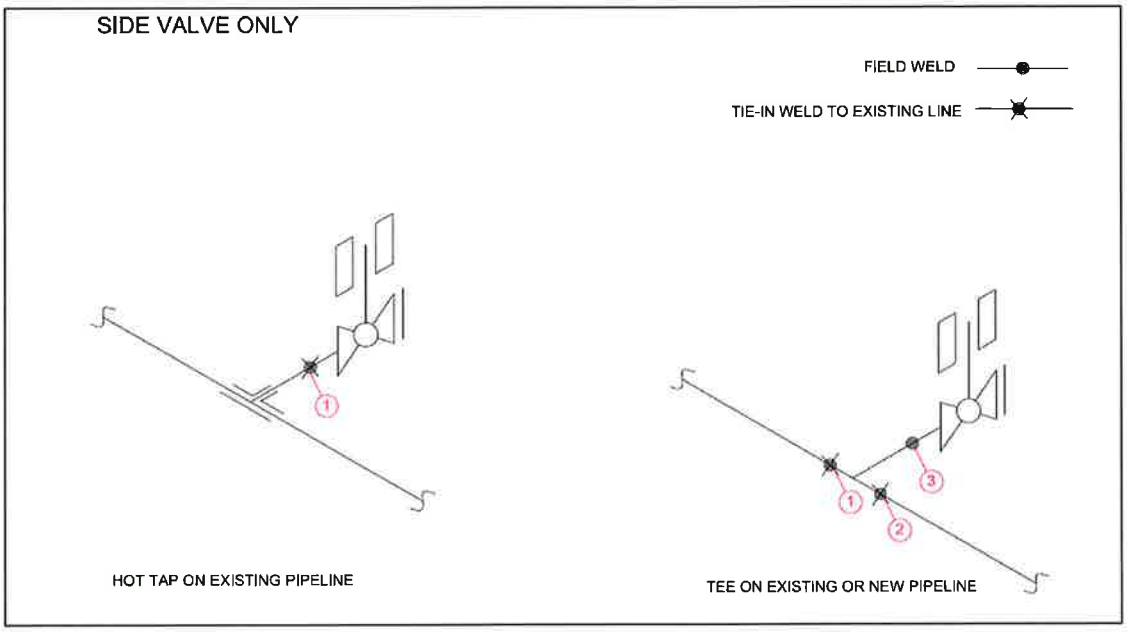
When a new side-valve assembly is required on an existing pipeline using a tee the number of non-pressure tested welds may be limited up to three.

**Rationale:**

Two welds are required to install the tee into the pipeline (weld 1 and 2) and one weld is required to weld the prefabricated valve assembly to the branch of the tee (weld 3). Weld 3 is required to ensure that the valve and stem are installed plumb (vertical). This is important to ensure proper functionality of the valve operator. The maximum allowable offset for the stem and operator is +/-4 degrees from vertical.

**Alternative:**

If survey information for the existing pipeline exists and can verify that the line is flat, the valve and tee assembly can be prefabricated and hydrotested in the fabrication shop. This would eliminate one non-pressure tested weld (weld 3). Note however that this design suffers from the risk that the existing pipe may spring out of its flat alignment when cut, so it is to be used with caution.




**Appendix Figure A-1: Side Valve Installation**

## A-2 METER STATION

Meter stations will be hydrotested in the field after fabrication, if required. Regardless of whether there is a single meter run or multiple meter runs, the installation may have up to four (4) non pressure-tested welds.

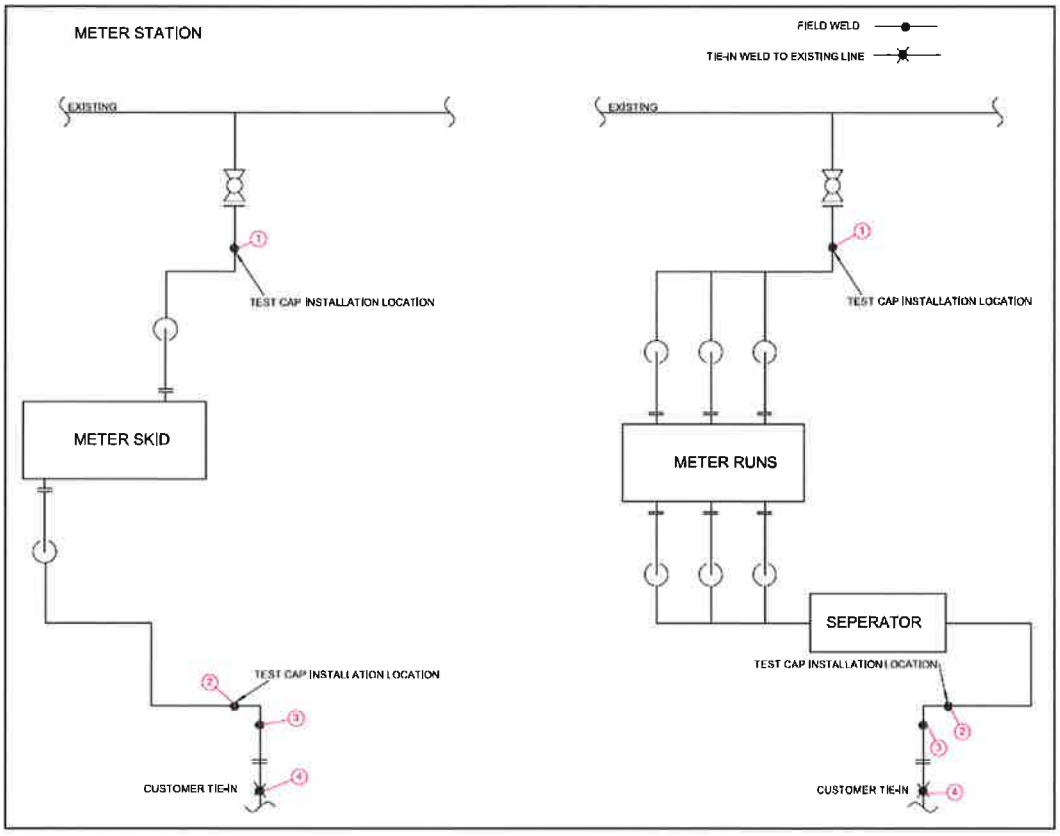
**Rationale:**

- Test caps will be utilized at both ends of the meter station yard piping.
- The Company side of the meter station will be tested from the test cap to the meter run flange(s). Due to limited space at the hot tap valve location a test cap is used instead of using the flange at the valve.
- The customer side of the meter station will be tested from the meter run flange(s) to the test cap. A test cap is used rather than breaking the pretested flange and insulating set assembly. The test cap location is due to the required location of the flange set. The insulating flange at the customer tie in point is placed 1 meter from the meter station boundary. This is to minimize the amount of pipe that is not protected by cathodic protection while maintaining the insulating set on the meter station boundary. Welds 1, 2, and 3 are due to the test caps and weld 4 is the final tie in to the customer.

**Alternative:**

- When space permits the Company side of the meter station shall be tested to the flange. This would eliminate one (1) of the non-pressure tested welds.

- On the customer side, rather than use a test cap, the flange and insulating set assembly shall be taken apart and the piping should be tested to the flange. This option increases the risk for potential leaks in the flange. This would however eliminate two (2) non-pressure tested welds.
- When space permits the test cap could be placed at weld three (3) which would eliminate one (1) non-pressure tested weld.




**Appendix Figure A-2: Meter Station**

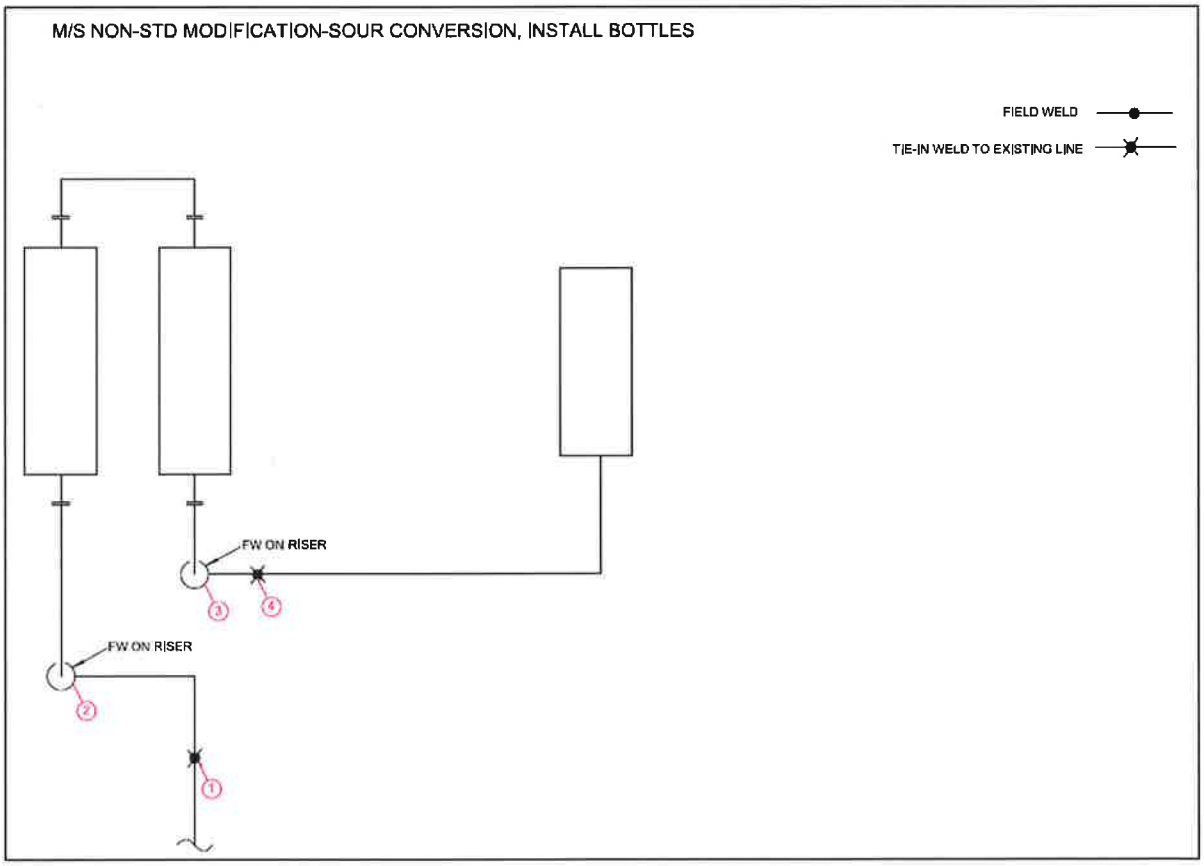
## A-3 SOUR CONVERSION ON EXISTING METER STATION

A sour conversion on an existing meter station may require the addition of one or multiple sour bottle(s). The number of non-pressure tested welds may be up to four.

**Rationale:**

The pipe connecting the existing station and the sour bottle(s) will require shop and field hydrotest. Some flexibility in the design is required due to the possible difference in elevation between the meter building, the sour bottles and the final tie in. Once the pipe has been field fit it can be field hydrotested. There will be two non-pressure tested welds on the risers on either

side of the sour bottles to ensure a stress-free tie in and two non-pressure tested welds to tie the new pipe to the existing pipe.




**Appendix Figure A-3: Sour Conversion on Existing Meter Station**

## A-4 NEW BLOCK VALVE ASSEMBLY ON NEW OR EXISTING PIPELINE

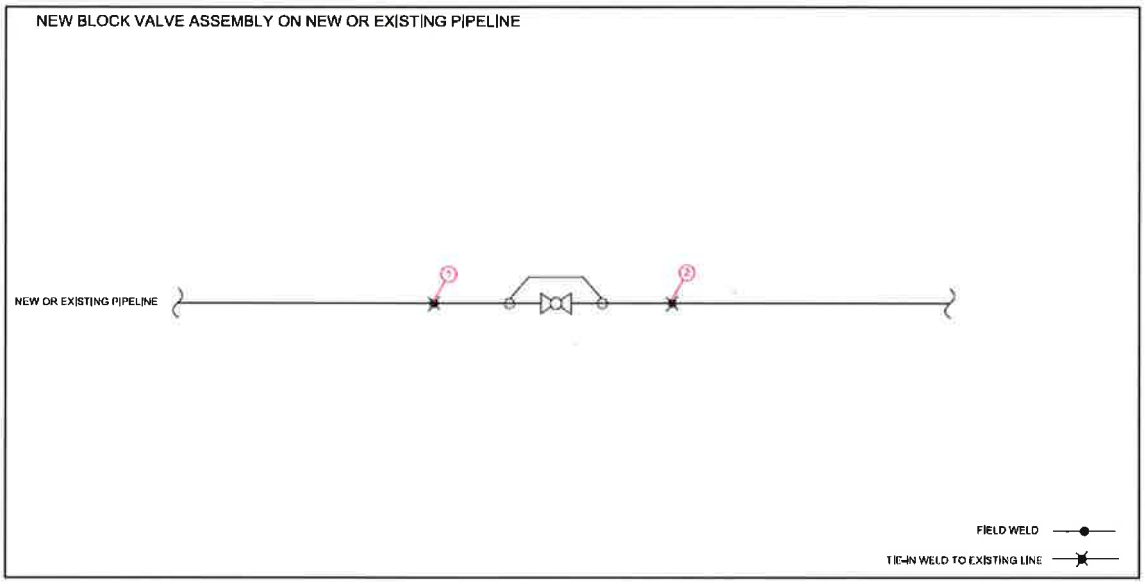
When installing a block valve there may be two non-pressure tested welds. Pre-fabricated and tested block valve assembly must include any required transitions to the existing pipe wall thickness.

**Rationale:**

The block valve assembly will be shop fabricated and hydrotested, or assembled and hydrotested on site depending on the size of the assembly. Regardless, there will be two tie in welds required for the installation of the assembly into the pipeline.

**Alternative:**

If the block valve assembly is installed on a new pipeline it could be hydrotested with the pipeline subject to evaluation of the risks and mitigations.




**Appendix Figure A-4: New Block Valve Assembly on New or Existing Pipeline**

## A-5 THREE VALVE CLUSTER AT PUMP STATION INSTALLED ON NEW OR EXISTING PIPELINE

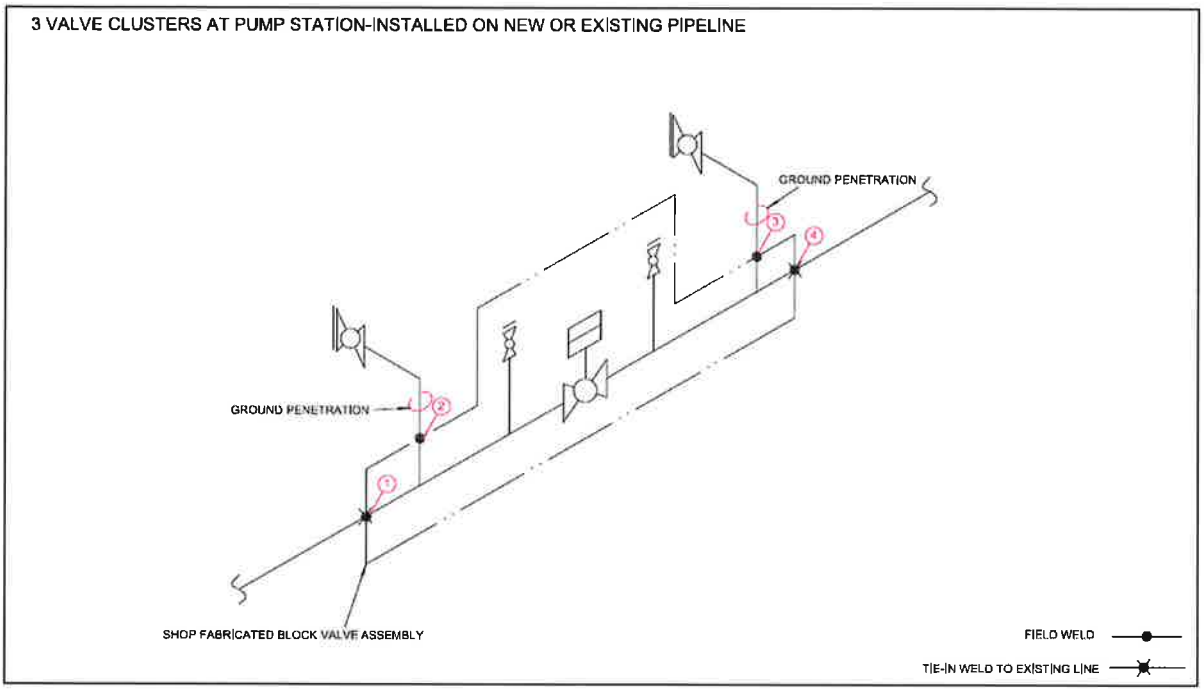
The three-valve cluster consists of a prefabricated block valve assembly complete with two pump outs and two side valves to connect the pump station. This layout may have up to four non-pressure tested welds.

**Rationale:**

Welds 1 and 4 are required to tie the valve assembly into the pipeline and weld 2 and 3 are required for a stress-free installation of the two side valves.

**Alternative:**

If the three-valve cluster is on a new pipeline it could be hydrotested along with pipeline subject to evaluation of the risks and mitigations.



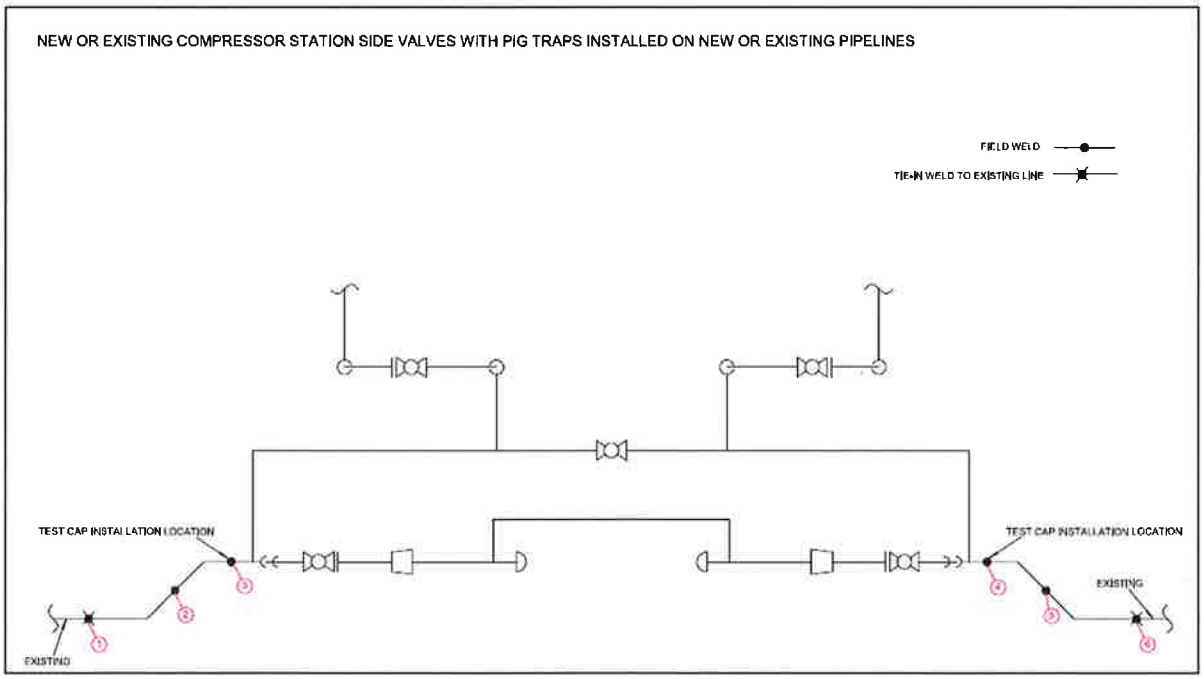

**Appendix Figure A-5: Three Valve Cluster at Pump Station Installed on New or Existing Pipeline**

## A-6 NEW OR EXISTING COMPRESSOR STATION SIDE VALVES WITH PIG TRAPS INSTALLED ON NEW OR EXISTING PIPELINE

This layout may result in six non-pressure tested welds. The pig trap and compressor station side valves are offset from the existing pipeline to reduce the outage on the existing pipeline and to allow for a stress-free tie in to the existing pipeline.

**Rationale:**

Two test caps will be installed, one on each side of the assembly, to facilitate a field hydrotest of all piping up to the flanges on the compressor station side valves. Once the test is complete the final tie in to the new or existing pipe will be done. To ensure a stress-free tie in there will be three non-pressure tested welds on either side to complete the tie in.




**Appendix Figure A-6: New or Existing Compressor Station Side Valves with Pig Traps Installed on New or Existing Pipeline**

## A-7 NEW PIPELINE SIDE VALVE AND NEW PIG TRAP

When a new side valve assembly and pig trap are required, the number of non-pressure tested welds may be up to eight plus those required to tie-in the kicker line  Refer to the side valve tie in options for the kicker line tie in welds (one or three depending on which option is chosen).

The flanged portion of the kicker line shall be field tested to eliminate any non-pressure tested welds on this section of pipe.

**Rationale:**

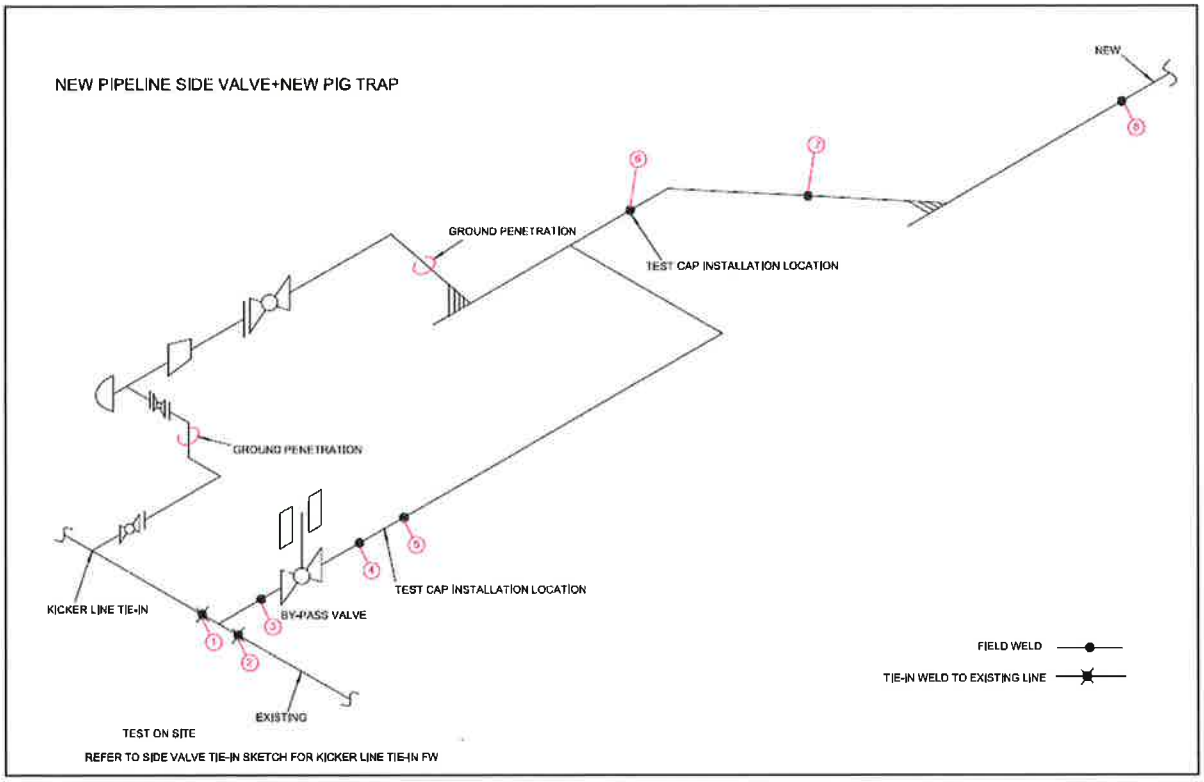
Welds 1 and 2 are required to install the tee into the existing pipeline, weld 3 is to weld the prefabricated valve assembly to the tee and is required to ensure that the valve is installed straight and the stem plumb (vertical). This is important to ensure proper functionality of the valve operator. The maximum allowable offset for the stem and operator is +/- 4 degrees from vertical. Welds 4 and 5 are required for the installation of one test head. Welds 6 and 7 are to ensure a stress-free tie in and weld 8 is for the final tie in to the pipeline.

**Alternative:**

- If possible a hot tap could be used for the connection of the bypass valve which would eliminate welds 1 and 2.
- If survey information for the existing pipeline exists and it can be verified that the existing line is flat the valve and tee assembly can be prefabricated. Perform a

shop hydrotest of the assembly. This would eliminate one non-pressure tested weld (weld 3).

- The test cap on the downstream side of the assembly could be placed near weld 8. This would allow weld 6 and 7 to be hydrotested. This would result in a second non-pressure tested weld near weld 8 where a section of pipe would need to be installed once the test cap was removed. This alternative would result in one less non-pressure tested weld, a total of 7, but would not have the benefits of the stress-free tie-in.




**Appendix Figure A-7: New Pipeline Side Valve and New Pig Trap**

## A-8 INSTALLATION OF A STANDARD PIG TRAP NPS 24 OR LARGER ON EXISTING PIPELINE

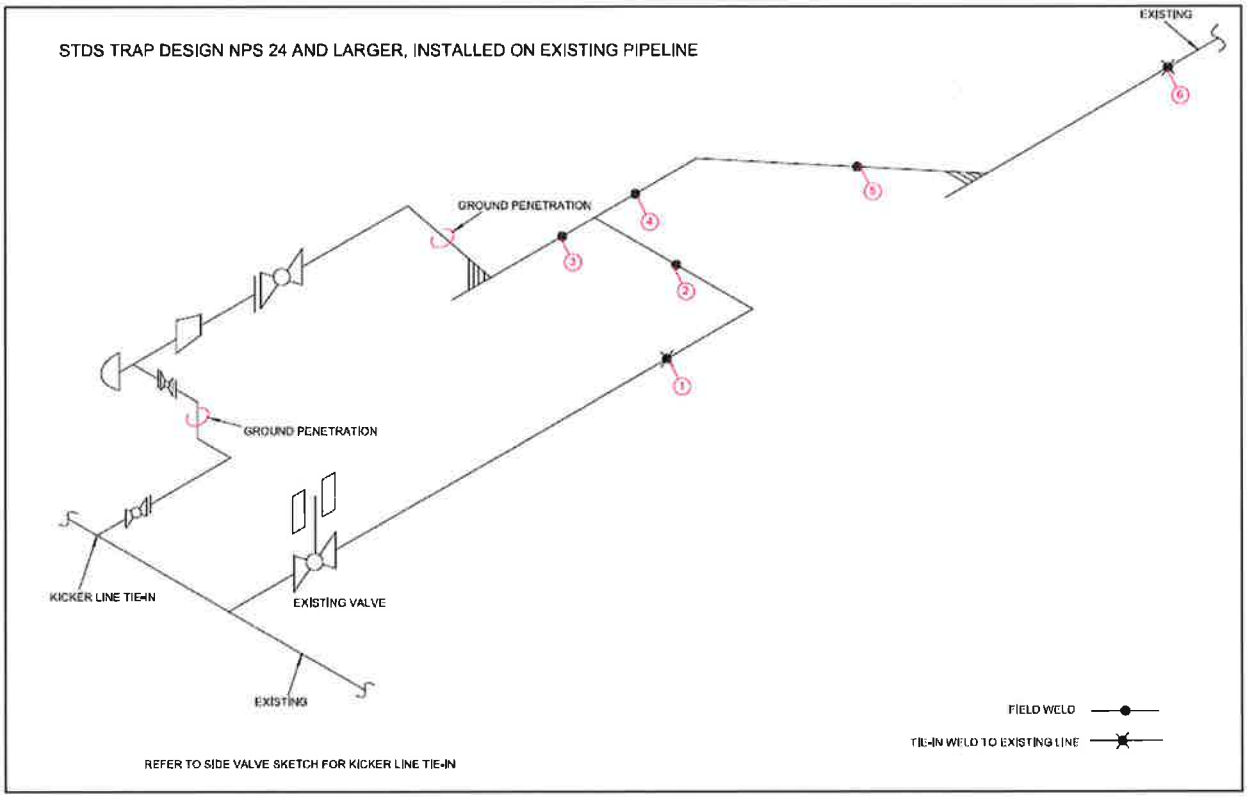
When installing a NPS 24 or larger standard pig trap on an existing pipeline the number of non-pressure tested welds may be up to six plus those required to tie-in the licker line. Refer to the side valve tie in options for the kicker line tie in welds (one or three welds depending on which option is chosen). Most of the pig trap piping will be tested in place. This will require the installation of two test caps. The flanged portion of the kicker line will be removed and tested in the field.

**Rationale:**

Since this is a new pig trap on an existing pipeline it is very difficult to test all pipe in place. The six non-pressure tested welds are to ensure a stress-free tie in.

**Alternative:**

Test caps could be installed on either end of the piping, which would result in four non-pressure tested welds. This is two less than the original design but the addition of two non pressure-tested welds to have adjustability for a stress-free tie in is the preferred option.



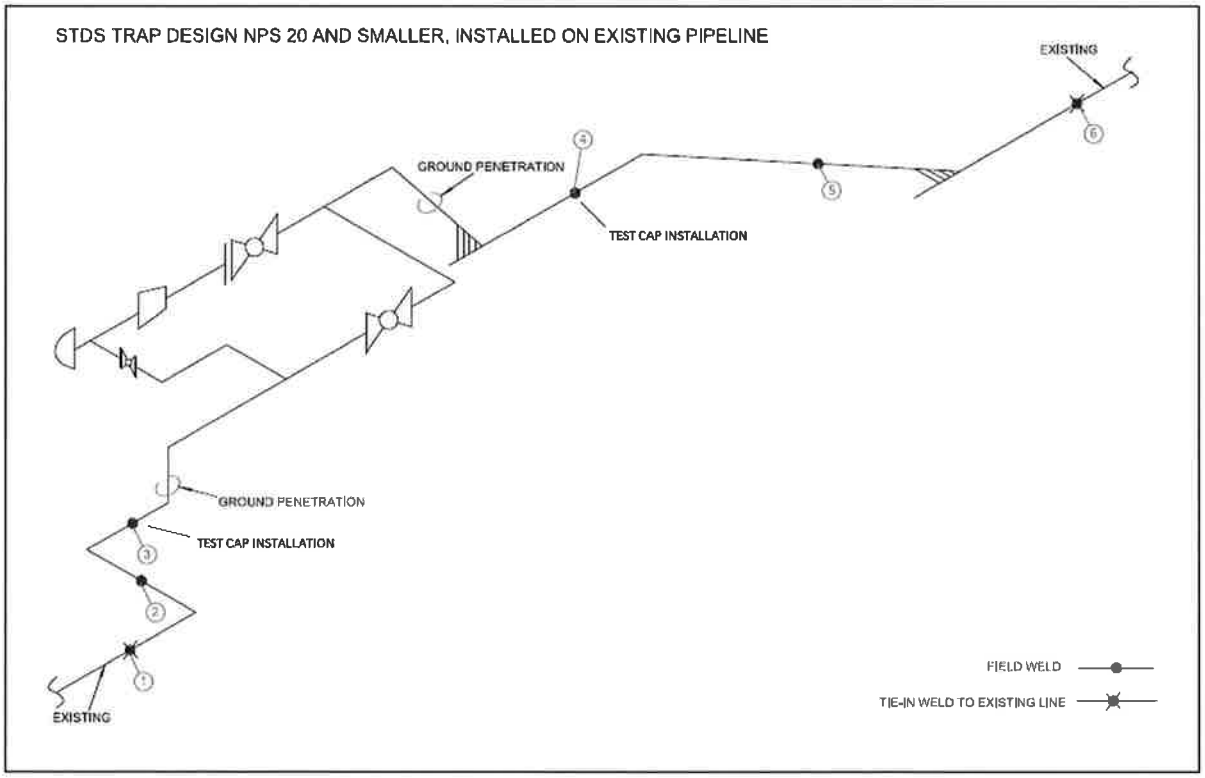

**Appendix Figure A-8: Installation of a Standard Pig Trap NPS 24 or Larger on Existing Pipeline**

## A-9 INSTALLATION OF A STANDARD PIG TRAP NPS 20 OR SMALLER ON EXISTING PIPELINE

When installing a NPS 20 or smaller standard pig trap on an existing pipeline the number of non-pressure tested welds may be up to six plus those required to tie-in the kicker line. Refer to the side valve tie in options for the kicker line tie in welds (one or three welds, depending on which option is chosen).

**Rationale:**

Test caps shall be placed at welds 3 and 4. This location is chosen as it allows for the required space necessary to perform a safe hydrotest. The six non-pressure tested welds are required for a stress-free tie in to the pipeline.




**Appendix Figure A-9: Installation of a Standard Pig Trap NPS 20 or Smaller on Existing Pipeline**

## A-10 PIPELINE LOOP AND CROSSOVER

The number of non-pressure tested welds is dependent on the type of tie in that is used on both the new and existing pipelines as well as whether the valve is located near the existing pipeline or the new pipeline.

## A-10-1 TEE ON NEW AND EXISTING PIPELINES AND VALVE LOCATED NEAR THE EXISTING PIPELINE

This design is required when the outage on the existing pipeline is prior to the construction of the new pipeline. There may be up to eight non-pressure tested welds

**Rationale:**

There will be two non-pressure tested welds on the tee which is installed on the existing line (weld 1 and 2), one for the installation of the valve (weld 3), three on the tee being installed on the new line (weld 6, 7 and 8), and two non-pressure tested welds on the crossover pipe to allow for a stress-free tie-in (weld 4 and 5). Weld 3 is required to ensure that the valve is installed straight and the stem plumb (vertical). This is important to ensure proper functionality of the valve operator. The maximum allowable offset for the stem and operator is +/-4 degrees from vertical.

**Alternative:**

- If survey information for the existing pipeline exists and it can be verified that the line is flat the valve and tee assembly can be prefabricated. Perform a shop hydrotest of the assembly. This would eliminate one non-pressure tested weld (weld 3).
- After the crossover pipe is in place the section from weld 4 to 6 could be removed and hydrotested. This would eliminate one non-pressure tested weld (weld 5). Weld 4 and 6 would still be non-pressure tested as they are required to tie in the crossover pipe. This would result in a total of seven non-pressure tested welds. This hydrotest could be done up to the flange which would then result in six non-pressure tested welds. This would require unbolting the pretested flange assembly which may result in an increased potential for leaks.

## A-10-2 TEE ON NEW AND EXISTING PIPELINES AND VALVE LOCATED NEAR THE NEW PIPELINE

This design is required if the new pipeline is installed prior to the outage on the existing line. There may be up to eight non-pressure tested welds.

**Rationale:**

There will be three non-pressure tested welds on the tee which is installed on the existing line (weld 1, 2 and 3), two on the crossover pipe to allow for a stress free tie in (weld 4 and 5), one for the installation of the valve (weld 6), and two on the tee being installed on the new line (weld 7 and 8). Weld 6 is required to ensure that the valve is installed straight and the stem plumb (vertical). This is important to ensure proper functionality of the valve operator. The maximum allowable offset for the stem and operator is +/-4 degrees from vertical.

**Alternative:**

- If the new pipeline is flat the valve and tee assembly can be prefabricated. Perform a shop hydrotest of the assembly. This would eliminate one non-pressure tested weld (weld 6).

- After the crossover pipe is in place the section from weld 3 to 5 could be removed and hydrotested. This would eliminate one non-pressure tested weld (weld 4). Weld 3 and 5 would still be non-pressure tested as they are required to tie in the crossover pipe. This would result in a total of seven (7) non-pressure tested welds. This hydrotest could be done up to the flange which would then result in six (6) non-pressure tested welds. This would require unbolting the pretested flange assembly which may result in an increased potential for leaks.

### A-10-3 TEE ON NEW PIPELINE AND HOT TAP ON EXISTING PIPELINE

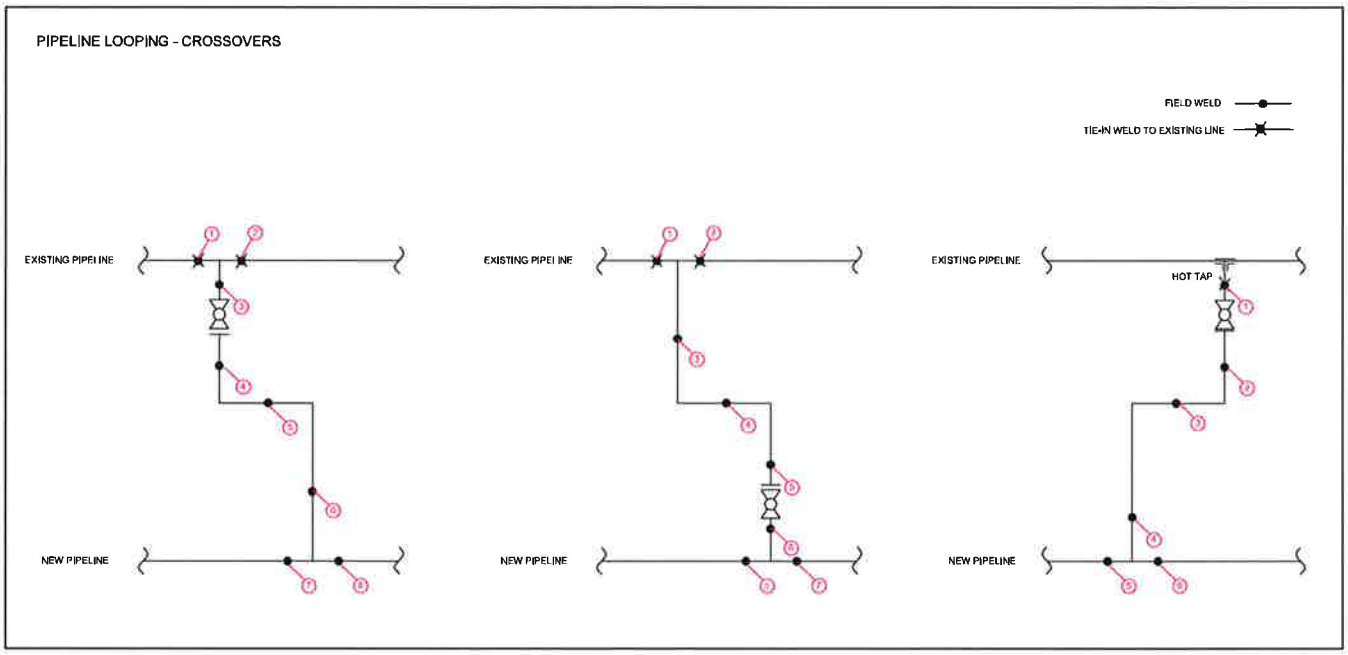
For this installation the valve is located near the existing pipeline. There may be up to six non-pressure tested welds.

**Rationale:**

There will be one for the hot tap on the existing line (weld 1), two non-pressure tested welds on the crossover pipe to allow for a stress free tie-in (weld 2 and 3), and three non-pressure tested welds on the tee which is installed on the new line (weld 4, 5 and 6).

**Alternative:**

- To eliminate the non-pressure tested welds on the tee installed on the new pipeline (weld 5 and 6) a test cap would need to be installed on the tee to allow it to be tested with the new pipeline. This would eliminate two non pressure-tested welds and the total would then be four.
- After the crossover pipe is in place the section from weld 2 to 4 could be removed and hydrotested. This would eliminate one non-pressure tested weld (weld 3). Weld 2 and 4 would still be non-pressure tested as they are required to tie in the crossover pipe. This would result in a total of five non-pressure tested welds. This hydrotest could be done up to the flange which would then result in four non-pressure tested welds. This would require unbolting the pretested flange assembly which may result in an increased potential for leaks.




**Appendix Figure A-10: Pipeline Loop and Crossover**

## A-11 PIPE REPLACEMENT

### A-11-1 SINGLE JOINT

When replacing one joint of pipe (for an integrity dig or reinstating a pipeline following a hydrotest for example), there may be up to two non-pressure tested welds

**Rationale:**

The replacement pipe, including any required counter bore and taper transitions, will be pre-tested in either shop or field. There will be two tie in welds required for the installation of the pretested pipe into the pipeline.

**Alternative:**

In cases where the pipeline moves/springs upon cut out or the actual pipeline alignment differs from what was assumed based on drawings and survey, a third weld (weld 3) may be added at one of the locations shown for stress free tie-in and weld alignment.

## A-11-2 PIPE REPLACEMENT – TWO JOINTS OR MORE

When replacing more than one joint of pipe, there will be two (2) non-pressure tested welds

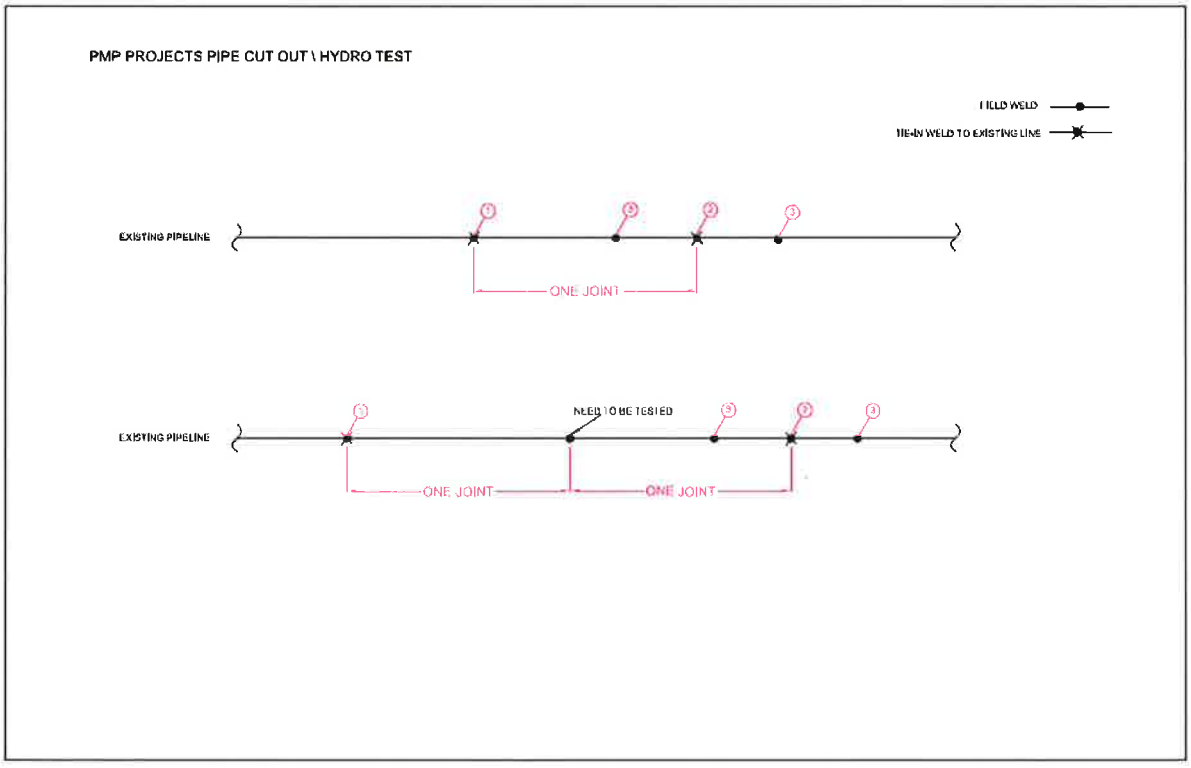
**Rationale:**

If the overall size is transportable, the replacement pipe will be shop fabricated and hydrotested and there will be two tie in welds required for the installation of the pretested pipe into the pipeline.

If the overall size is too long for transportation, the replacement pipe will be field hydrotested, there will be two tie in welds required for the installation of the field-tested pipe into the pipeline.

**Alternative:**

In cases where the pipeline moves/springs upon cut out or the actual pipeline alignment differs from what was assumed based on drawings and survey, a third weld (weld 3) can be added at one of the locations shown for stress free tie-in and weld alignment.




**Appendix Figure A-11: Pipe Replacement – Single and Multi-Joint**

## APPENDIX B SCHEDULE OF NON-PRESSURE TESTED WELDS (SAMPLE FORM)

| | |
|---|---|
| **Project Name:** | |
| **Project Number:** | |
| **LSD:** | |
| **FIA Number:** | |

| Weld Code or Number | Drawing Reference # (Plot Plan, Isometric, Tie-in Sketch) | Justification (if Not Tested) | TEF-WELD-TIE-IN Completed (Initials) |
|---|---|---|---|
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Contractor's Inspector: Name _____ Signature _____

Owner's Inspector: Name _____ Signature _____

## APPENDIX C SAMPLE TEST HEAD DRAWINGS

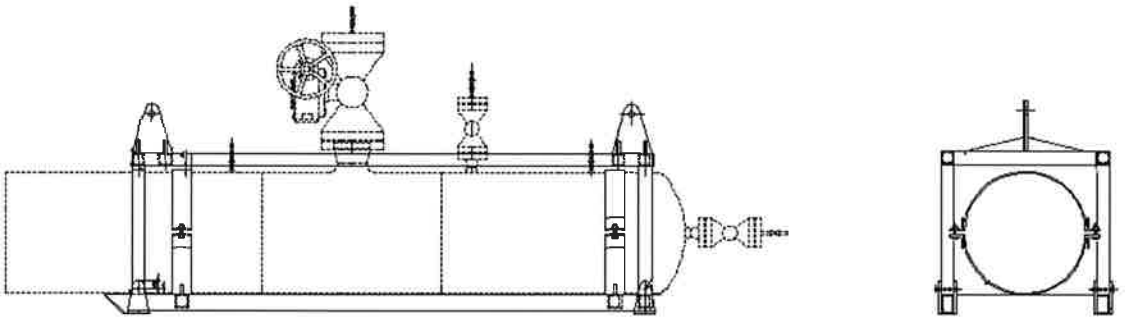

**Figure C-1: Sample Test Head with Cradle Layout**

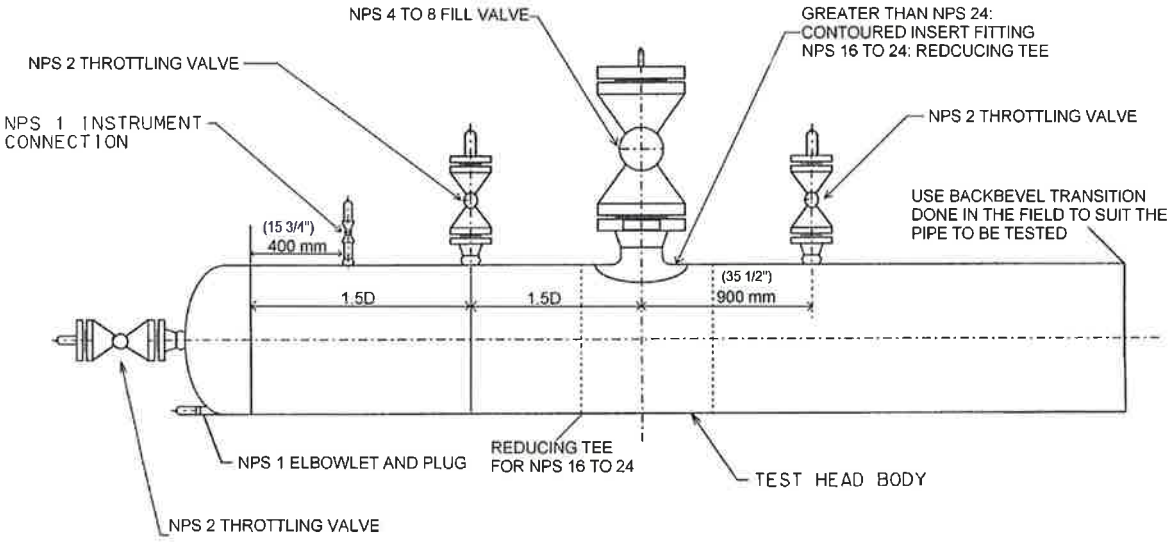


**Figure C-2: Sample Test Head Layout (NPS 16 to NPS 48)**

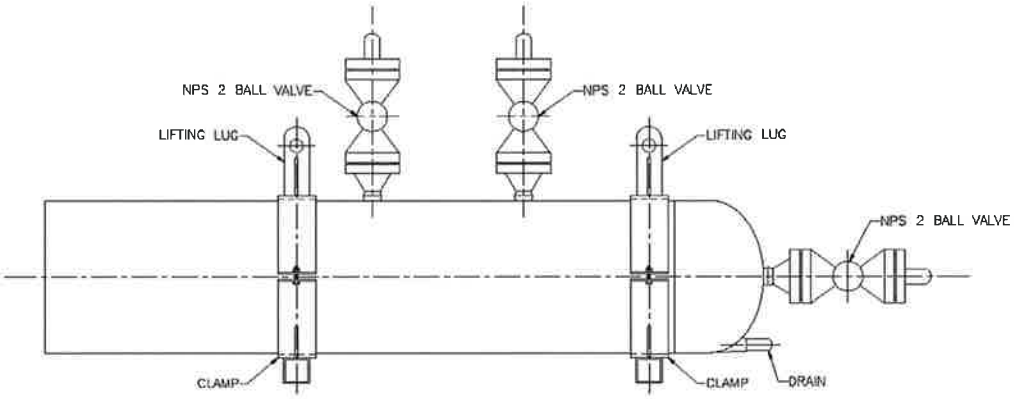


**Figure C-3: Sample Test Cap Layout (NPS 12 to NPS 48)**

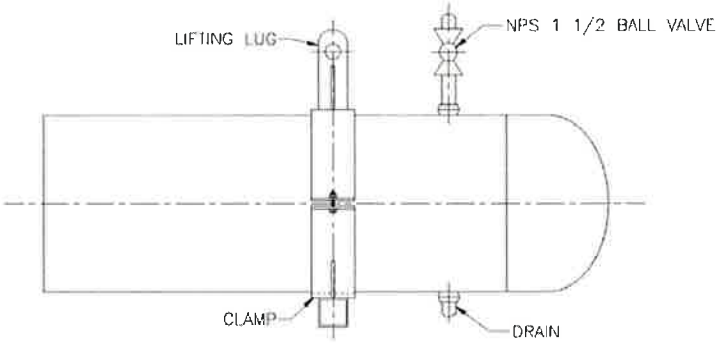


**Figure C-4: Sample Short Test Cap Layout (NPS 12 to NPS 48)**

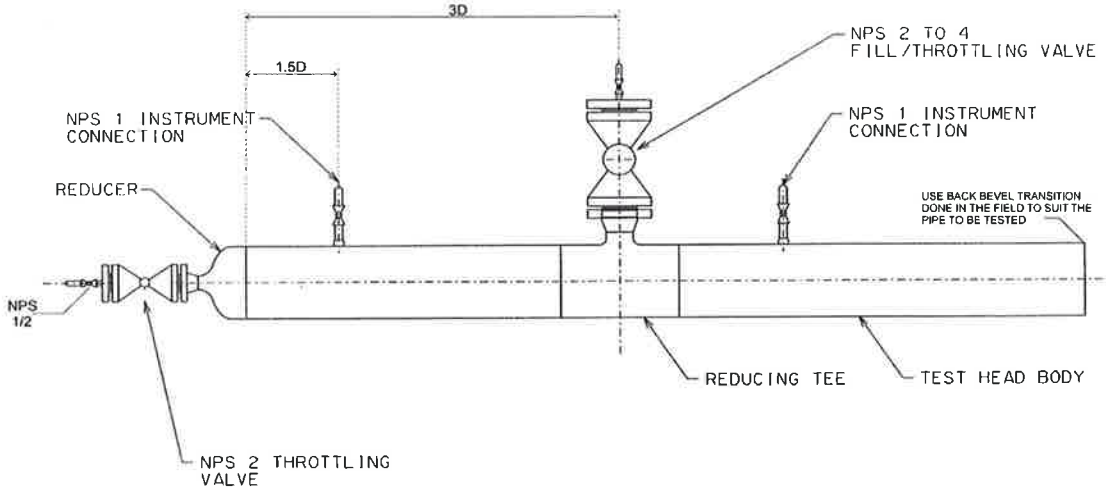


**Figure C-6: Sample Test Head Layout (NPS 3 to NPS 12)**

# TES-COAT-EPU Field-Applied External Liquid Coating Systems for Steel Pipes Specification (CDN-US-MEX)

EDMS No.: 3671710 Rev.: 13 Status: Issued Effective Date: 2016-Nov-08
Next Review Date: 2018-Nov-08

## PURPOSE

This Specification describes the minimum requirements for external liquid coatings to be used for below ground corrosion control on pipelines and facilities.

## SCOPE / APPLICABILITY

This Specification covers shop and field-applied external liquid coatings and includes requirements for:

- Application
- Inspection
- Handling
- Repair and maintenance

This Specification also covers holiday detection and repairs to fusion bond epoxy (FBE) coating with liquid coatings.

This Specification applies to Canada, the United States and Mexico.

U.S. and Mexico projects shall follow the body of this Specification for all coating application except the requirements listed in APPENDIX B. Canadian projects shall follow the body of this Specification, APPENDIX B, and the coating Manufacturer's Qualified Application Procedure (MQAP).

The following activities fall outside of the scope of this document:

- Coating of Mueller tees
- Sealing above ground support sleeves to eliminate water migration through the sleeve
- Coating the edge transition of clamps

Find details on these activities in TES-COAT-PET (EDMS No. 7756).

The Applicator Selection Process falls outside of the scope of this Specification.

Contact the Responsible Engineer for clarification.

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# 1 GLOSSARY

**ABR**

Abrasion resistant coating also known as ARO or abrasion resistant overlay which is to be used in abrasive conditions.

**Applicator**

Company responsible for the actual application of the coating. Typically, this is either the Contractor or their sub-Contractor.

**Cohesive Failure**

The separation of the homogeneous coating. Coating left on the steel substrate and coating forced off during evaluation.

**Company**

TransCanada, including its affiliates, engineering agencies, inspectors and other authorized representatives.

**Company Coating Inspector**

A designated coating inspector hired by the Company for the duration of the Project.

**DFT**

Dry film thickness, the thickness of the coating after it has hardened to a solid state, as defined in SSPC PA2.

**Epoxy**

A two-component liquid epoxy coating system.

**Liquid Coating**

A coating material, consisting of two or more parts in a fluid state, that when mixed together and applied to the substrate hardens to form a solid coating. Usually formulated from epoxy or urethane resins. Also referred to as ‘two-component liquid epoxy’ or “two-part epoxy coating”.

**Pre-fabricated valve assemblies**

Pre-fabricated valve assemblies are assemblies that have been bolted/welded together. Pipe pups, valves, elbows, check valves and flanged items that are already fabricated prior to coating and to be installed as one piece into the facility being constructed.

**Service Temperature**

The maximum operating temperature that the coating will see during its lifecycle

**Single Gauge Reading**

One single reading taken by a DFT gauge.

**Sweating/Damp Pipe (Substrate)**

Any substrate to be coated or abrasive blasted is considered to be sweating or damp if its temperature is less than 3 Celsius degrees (3C°) (5 Fahrenheit degrees (5F°)) above the dew point of the air immediately adjacent to the surface.

**System 1A**

Single-layer fusion bond epoxy (FBE) corrosion coating.

**System 2B**

Two-layer fusion bond epoxy (FBE) coating (comprised of a corrosion coating (System 1A) and an abrasion resistant overcoat).

**Turnover Package**

Contractor generated coating application QA/QC records for the project with required calibration certificates included.

**WFT**

Wet film thickness. The thickness of the coating film while in the liquid state.

**Tape**

Over the ditch mechanically applied or hand-wrap tape systems, excluding petrolatum tape system.

## 2 REQUIREMENTS

### 2.1 General Requirements

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

2.1.2 The Applicator is responsible to adhere to the requirements outlined in this Specification.

2.1.3 Prior to bidding, the Applicator's personnel shall be Manufacturer trained and certified for the specified product application.

2.1.4 Certification shall be renewed annually.

2.1.5 Copies of all certificates of qualification shall be supplied to the Company's onsite Coating Inspector for review and acceptance.

2.1.6 The Company shall approve all Plural Component Spray and Automated Spray Application companies prior to award of bid.

2.1.7 The Applicator shall provide at least one NACE certified CIP Level I or Company approved alternatively trained employee at their shop or field location. This employee shall perform inspections and supervise other employees conducting inspections. This employee shall have thorough knowledge of the application procedures used for high performance coatings and be competent with procedures used to apply liquid coatings.

2.1.8 The Applicator shall ensure compliance with all applicable regulations, codes, standards, and specifications.

2.1.9 Below ground metallic components (e.g., girth welds, piping, valves, fittings, and structural steel) shall be coated according to APPENDIX A. Items shall be handled in such a manner so as to prevent them from being damaged.

2.1.10 In addition to the Manufacturer's training, Plural Component and Automated Spray Applicators shall have one of the following:

- The Society for Protective Coatings (SSPC) QP1 or QP3 certifications as applicable
- National Association of Corrosion Engineers (NACE) NIICAP AS-1 accreditation
- ISO 9001 Quality Management Standard certifications
- A documented company Quality Management System

2.1.11 The Applicator shall submit an inspection and test plan (ITP) for the Project for the supply and application of coating materials to the Company's onsite Coating Inspector or Responsible Engineer prior to the commencement of work. The ITP is a live document. It shall be created prior to application and shall be updated when required to be representative of the work being performed throughout the project.

2.2 Surface Preparation

2.2.1 Prior to abrasive blasting, perform the following:

- Examine the surface for the presence of any materials such as existing coatings or heavy corrosion that will require removal.
- If any such materials are present, and cannot be removed by abrasive blasting, conduct a pre-blast surface cleaning.
- After removal, inspect the surface again to ensure that any material remaining may be readily removed during abrasive blasting.

2.2.2 Monitor and record ambient conditions as follows:

- Measure the surface temperature, dew point, and relative humidity at the beginning of each shift and every four hours thereafter. If ambient conditions change, additional measurements shall be taken.
- Maintain a dry surface and a surface temperature of at least 3° C (5° F) above the dew point temperature (do not exceed 150°C (302°F)).
- Adhere to the Manufacturer's recommendations for surface temperature from abrasive blast cleaning until the coating cures.

2.2.3 Ensure surfaces to be abrasive blast-cleaned are free of oil, grease, slivers, mud, soils, rough welds, burrs, weld spatter, etc. Solvent clean any oil, grease, or other foreign material in accordance with SSPC-SP-1.

2.2.4 Verify that the surfaces do not contain detrimental levels of non-visible soluble salt contamination. Do not perform any coating until the surface is cleaned to a chloride level less than or equal to 20 mg/m² or 3 ppm. Test the blast-cleaned surface. Salt testing prior to blast cleaning is not required but should be performed to facilitate salt removal by distilled water washing in case the presence of salt is discovered. Salt testing frequencies are listed in Section 2.14 of this Specification.

2.2.5 Protect machined surfaces, moving parts, the edge of weld bevels, internal surfaces, and raised faces of flanges from damage during abrasive blast cleaning and coating application. Prevent blast media and coating material from entering the valves, fittings, and pipe. No amount of blast media in a valve, fitting, or pipe shall be acceptable.

2.2.6 Abrasive blast-clean the exterior metal surface to a near white finish SSPC-SP-10 (NACE # 2 or Sa 2 ½ per ISO 8501-1:2007 = SIS 055900) or better.

2.2.7 Edges of the existing coating shall be roughened by power sanding or by sweep blasting coating for a minimum distance of 5 cm (2 in). All roughened coating shall be coated.

2.2.8 The following abrasives are approved by the Company as they produce the angular profile required for correct coating application and contain no oil/grease or soluble salts:

- Green Diamond
- Black Beauty
- Black Magic
- Starblast XL
- Black Shot II
- Black Lightning

A Company-approved equivalent may be used. Contact the Responsible Engineer for approval of any alternative equivalent abrasives. Do not use copper-bearing abrasives and steel shot.

2.2.9 Ensure the abrasive blast media is dry, has a neutral pH, and contains no contaminants injurious to the performance of the paint.

2.2.10 If Company approved abrasives are used, soluble salt or oil contamination testing on the abrasive is not required providing they are packaged and stored in accordance with the Manufacturer's recommendations.

2.2.11 If an alternative equivalent abrasive is used, conduct soluble salt or oil contamination testing daily. If the Company's onsite Coating Inspector suspects the abrasive being used is contaminated or is not listed in the approved abrasive list, testing of the abrasive is required.

2.2.12 Test bulk orders of abrasive once per load to confirm that each shipment of abrasive does not contain soluble salts or oil contamination. The chloride content during testing shall not exceed 3 ppm (3 mg/L) and no oil shall be present when visually examined after remaining in the distilled water for 30 minutes. Contact the Responsible Engineer for the testing procedure if required

2.2.13 Material for abrasive cleaning shall produce an angular surface profile as indicated in Table 2-1. If higher profiles are achieved, contact the Responsible Engineer to determine acceptance.

2.2.14 Measure and record the anchor profile using replica tape and a spring micrometer in accordance with NACE RP0287. Ensure the frequency and number of readings in accordance with Section 2.13.

2.2.15 Sweep blast metal areas that develop flash rust due to exposure to rain, moisture, or humidity to return them to their original abrasive blast-cleaned condition. Coat the blasted surface immediately.

2.2.16 Ensure the compressed air supply used for abrasive blast cleaning or conventional spraying is free of water and oil. Use separators and filters on the compressed air supply to ensure that contaminants such as oil and water do not contaminate the steel surface. Perform a blotter test in accordance with ASTM D4285 at the start of every working day to verify the cleanliness of the compressed air.

2.2.17 Retest any abrasive blasting unit or compressed air used for conventional spraying that fails testing. If the second test fails, take the unit out of service until the unit is repaired and can pass the blotter test.

2.2.18 Remove residual abrasive blast products from the entire abrasive blasted surface. Use one of the following methods:

- Dry and clean bristle brush
- Vacuum
- Dry and clean compressed air.

2.3 Approved Coating Materials

2.3.1 Refer to Table 2-1 for Company-approved external liquid coatings.

Note: Order materials in spray grade or brush grade, as required.

**Table 2-1: Approved Coating Materials**

| Coating Manufacturer | Coating Product | Max. Operating Temperature | Service | Surface Profile | Dry Film Thickness (DFT) |
|---|---|---|---|---|---|
| Denso | 7200* | 90°C (195°F) | Non-abrasive conditions | 65 to 115 µm (2.5 to 4.5 mils) | 510 to 890 µm (20 to 35 mils)+ |
| | | | Abrasive conditions | | 1020 to 1780 µm (40 to 70 mils) |
| 3M | 327 | 90°C (195°F) | Non-abrasive conditions | 65 to 115 µm (2.5 to 4.5 mils) | 510 to 890 µm (20 to 35 mils)+ |
| | | | Abrasive conditions | | 1020 to 1780 µm (40 to 70 mils) |
| Specialty Polymer Coatings | 2888 RG | 90°C (195°F) | Non-abrasive conditions | 65 to 115 µm (2.5 to 4.5 mils) | 510 to 890 µm (20 to 35 mils)+ |
| | | | Abrasive conditions | | 1020 to 1780 µm (40 to 70 mils) |
| Specialty Polymer Coatings | 3888 | 90°C (195°F) | Non-abrasive conditions | 65 to 115 µm (2.5 to 4.5 mils) | 510 to 890 µm (20 to 35 mils)+ |
| Specialty Polymer Coatings | 6888 | 90°C (195°F) | Non-abrasive conditions | 65 to 115 µm (2.5 to 4.5 mils) | 510 to 890 µm (20 to 35 mils)+ |
| | | | Abrasive conditions | | 1020 to 1780 µm (40 to 70 mils) |
| Specialty Polymer Coatings | 8888 | 130°C (265°F) | Non-abrasive conditions | 65 to 115 µm (2.5 to 4.5 mils) | 510 to 890 µm (20 to 35 mils)+ |
| | | | Abrasive conditions | | 1020 to 1780 µm (40 to 70 mils) |

**Notes:**

* Spray product available in Canada as Denso Protal 7250.

\+ If the Applicator decides to apply higher film thicknesses, a maximum DFT of 1,780 µm (70 mils) is allowed at no extra cost to the Company.

2.3.2 No alternative materials are acceptable.

2.3.3 Do not add solvents to the liquid coating system.

2.3.4 Coating material shall be identified with the following:

- Manufacturer's name

- Product description
- Batch number
- Date of manufacture or expiry date

2.3.5 Coating materials shall be handled, stored, and within their shelf life in accordance with the Manufacturer's recommendations at all times.

2.3.6 Spray-applied coating shall be plural component airless spray applied using a Hydra-Cat (or Company approved equivalent) and necessary ancillary equipment in accordance with the Manufacturer's recommended practice.

2.3.7 The approved materials in this Specification do not address sweating pipe conditions or flowing pipe below 10ºC (50ºF). Contact the Responsible Engineer for the approved list of materials for use in these conditions.

2.4 Preheating–General

2.4.1 Maintain the surface temperature of the substrate within the Manufacturer's recommended range from abrasive blasting through coating cure. If that range will not be available from ambient conditions, use preheating. Preheating may also be used to accelerate cure when there are time or weather constraints.

2.4.2 Preheating or accelerated curing require Company approval if not outlined in Sections 2.5 and 2.6.

2.5 Preheating—Brush and Automated Spray Preheat

2.5.1 In subzero temperatures, ensure that all snow, ice, or moisture is removed from the substrate prior to abrasive blasting. Preheating before abrasive blasting is not required if snow, ice, or moisture are not present and the steel substrate temperature is 3C° (5F°) above the dew point temperature.

2.5.2 Where direct flame is applied, abrasive blast-clean the surface, in accordance with this Specification.

2.5.3 Measure the pipe surface temperature using a contact surface thermometer.

2.5.4 Ensure preheating does not damage the mainline coating or the coating being repaired.

2.5.5 For girth weld coating perform the following:

- Preheat the surface if the pipe surface temperature is below 10˚C (50°F).
- Raise the surface temperature so that coating application takes place when the pipe surface is at or above the minimum temperature as specified. Do not apply direct flame to the pipe after blast cleaning.
- If heating is required after blast cleaning, and up until a full cure is achieved, use induction coils, infrared, or indirect heat to either maintain the surface above 10°C (50°F) or accelerate cure.

2.6 Preheating—Plural Component Spray Preheat

2.6.1 Shop Application: Carry out preheating or post curing only by increasing the ambient air temperature of the shop.

2.6.2 New Field Construction: Carry out preheating or post curing only by increasing the ambient air temperature with the use of hording and forced air heaters.

2.6.3 In-Service Facilities: Preheating should not be attempted. Ambient heating can take place prior to the coating operation provided the increase in temperature does not cause the pipe to sweat. Ambient heating can only be used if the flowing line temperature is below 10°C (50°F), with the substrate being a minimum of 3ºC (5ºF) above the dew point. It is recommended that coating application take place without ambient heating. Once the coating application is complete, start forced air heating, to increase the ambient air temperature within the hording, to post cure the coating.

Note: Post curing in New Field Construction and In-Service Facilities may lead to the formation of amine blush on the exterior surface of the applied coating. Do not conduct repairs until the amine blush has been removed in accordance with Section 2.11 of this Specification.

2.7 Coating Application—General

2.7.1 Follow Manufacturer's recommendation for acceptable substrate temperature range for coating application.

2.7.2 Overlap existing coating by a minimum distance of 5 cm (2 in.). Ensure feathered and roughened areas of existing coating are completely covered by the overlap.

2.7.3 Ensure finished coating is generally smooth and free of application defects (e.g., pinholes, fish eyes, sags, and holidays). Excessive drips, running, sagging, or other discontinuities shall be cause for rejection.

2.7.4 The Dry Film Thickness of the cured coating shall be as outlined in Table 2-1.

2.7.5 There is no restriction to pipe length for hand coating. The Project is responsible for deciding the application method chosen for the project.

2.7.6 Line pipe coated in accordance with this Specification may be used for operations such as horizontal directional drills and road bores. This coating shall not be cold bend in the field. If field bending is required, obtain Company approval prior to bending.

2.7.7 Handling or backfilling is not permitted until the coating cures, as determined by the Company's onsite Coating Inspector. Cure may be accelerated by post heating. Post heat only by an indirect method such as induction, ambient temperature, or infrared. Direct flame is permissible for tie-in welds but take care to ensure the coating does not char or burn. Do not touch the newly applied coating with the flame. The post heat temperature of the coating surface should not exceed the Manufacturer's recommended application temperatures.

2.7.8 Coating shall be holiday inspected as per section 2.18.

2.7.9 Coating shall be tested for adhesion as per section 2.17.

2.7.10 Coating shall be tested for cure as per section 2.16.

2.8 Coating Application—Plural Component Spray

2.8.1 Brush grade liquid coating material may be used to stripe-coat hard to spray areas, sharp edges and repairs. Ensure stripe coat is within recoat window, if not the stripe coat shall be abraded prior to the spray application.

2.8.2 Measure the wet film thickness (WFT) of the applied coating using a wet film gauge and consider the following:

- Brush out or spray over any marks.
- Take wet film measurements on every component (e.g., joint, elbow, tee, and piping) being coated.
- Apply additional coating if low areas are detected before tack-free condition occurs.

2.9 Coating Application—Automated Spray Application

2.9.1 Do no override any warning alarms produced by the monitoring system for the automated application unit unless it is in the system requirements and is stated in the ITP. Inform the Company's onsite Coating Inspector of warning alarms or system upsets in a timely manner.

2.9.2 Be cautious to prevent overspray of the coating material. Consider the following:

- Use welding shacks as enclosure structures to prevent overspray.
- If welding shacks are not available, then an approved alternative may be used.
- Submit details around the alternate enclosure to the Company's onsite Coating Inspector or Responsible Engineer for review and approval. The Company's onsite Coating Inspector or Responsible Engineer shall provide written acceptance of the alternate structure deeming it suitable for use.

2.9.3 Replace the spray tip every 50 km or 4000 applications, whichever comes first, regardless of acceptable visual performance. Replace the spray tip immediately if it fails the visual performance test.

2.9.4 Provide downloadable data acquisition application parameters to the Contractor and the Company's onsite Coating Inspector daily for review.

2.10 Coating Repairs—General

2.10.1 In general, use the same material for repairs as the parent coating. Use a brush grade material to repair a spray grade parent coating where applicable.

2.10.2 Repair FBE corrosion coating (System 1A), and FBE corrosion coating with FBE abrasion coating (System 2B), with a suitable liquid coating material selected from the materials listed in Section 2.3. Inspect System 1A and 2B coatings in the field and repair any damage found (e.g., scratches, scrapes, and gouges). At the discretion of the Company's onsite Coating Inspector, repair any visual imperfections that could

shorten the longevity of the plant-applied or newly applied coating systems, even if a holiday has not been detected.

2.10.3 Mark and repair any coating damage (e.g., scrapes and gouges) that have disrupted or reduced the coating film thickness to less than the specified thickness. Report the damage to the Responsible Engineer if gouges in the coating extend to the steel substrate and if damage to the steel seems to have occurred. Only repair the coating damage after the condition of the steel has been assessed and approval has been given by the Responsible Engineer.

2.10.4 Ensure repairs to coatings are in accordance with the requirements below:

- Small repairs: For repairs up to 2 mm (1/16 in.) in diameter, roughen the surface of the parent coating to remove gloss around the holiday to a distance of at least 25 mm (1 in.). Use 80 to 120 grit sandpaper or light sweep blasting.
- Medium sized repairs: For repairs up to 25 $cm^2$ (4 $in^2$) in area, prepare surface by abrasive blasting or by power tool cleaning in accordance with SSPC-SP 11 to remove dirt, scale, rust, damaged coating, and other foreign material (to a bare metal condition), and to retain or produce the surface profile required. During power tool cleaning, maintain the original profile depth if possible. Repair areas prepared with either method shall be monitored and be in accordance with this Specification.
- Large repairs: Surfaces of repair areas exceeding 25 $cm^2$ (4 $in^2$) shall be prepared by abrasive blast cleaning.

2.10.5 Roughen the adjacent parent coating and any holidays or damaged coating adjacent to the cutback area (e.g., welding band leg damage) for at least 25 mm (1 in.) around the repair and feather the edges.

2.10.6 After abrading, remove all dust from the prepared areas using compressed air, a clean, dry bristle brush, a clean, dry, lint-free cloth, or in accordance with SSPC-SP-1 using acetone, xylene, MEK, or any other solvent approved by the Manufacturer.

2.10.7 Cover the defect area entirely with the coating repair material and overlap the parent coating by a minimum of 25 mm (1 in.). Apply the repair material in accordance with Section 2.7.

2.10.8 Overcoating of pinhole, holidays, and repairs shall not exceed a total DFT of 1,270 µm (70 mils) for a 150 mm (6 in.) radius around the holiday.

2.10.9 Preheat the surface to be recoated when the surface temperature is below the minimum required by the Manufacturer.

2.10.10 Depending on the application type, various methods may be used to preheat or post heat to accelerate the cure of small and medium sized repairs. The Applicator shall inform the Company's onsite Coating Inspector, in writing, as to the proposed method. The Company's onsite Coating Inspector will review to ensure that the method does not damage the coating or contaminate the steel.

2.11 Coating Repairs—Overcoating Existing Coatings

2.11.1 Inspect the surface to be overcoated as follows:

- Confirm the surface is not contaminated with amine blush, oil, grease, or other contaminants. Do not overcoat the contaminated areas if amine blush or other contamination is suspected.
- Solvent-wash the contamination in accordance with SSPC-SP1 solvent cleaning prior to surface preparation.
- If the contamination cannot be removed, strip and reapply the coating.

Note: Epoxies develop amine blush during curing when exposed to water (e.g., rain), cool or humid conditions, or ambient air containing high levels of carbon dioxide. Liquid coatings that develop amine blush have a duller gloss, versus a liquid coating that has cured properly, and are slightly tacky to the touch.

2.11.2 Liquid coatings are permissible on full lengths of piping for abrasive conditions (e.g., HDDs and road bores). Apply liquid coatings directly to bare steel or over existing FBE System 1A coated pipe.

2.11.3 The Company's preferred method is FBE abrasion resistant coatings applied in accordance with TES-COAT-FBE (EDMS No. 3670892). However, the Project may approve liquid coatings. Spray application is the preferred application method of abrasion resistant coatings. However, the Project may choose to conduct the application by hand when required. Applications may take place in the shop or the field.

2.11.4 Roughen FBE System 1A coated pipe by sweep blasting to remove gloss and provide a minimum anchor profile of 13 to 38 µm (0.5 to 1.5 mils).

2.11.5 Upon completion of the surface preparation, conduct a DFT survey to establish the remaining average FBE coating thickness.

2.11.6 All coated surfaces shall have a minimum total DFT of 1020µm (40 mils) comprising the measured average FBE thickness and the applied abrasion resistant coating material. The maximum total DFT shall be 1780 µm (70 mils) comprising the measured average FBE thickness and the applied ABR coating material.

2.11.7 All listed products in Table 2-1 are acceptable for use as an overcoating for existing FBE System 1A and direct to bare steel pipe for abrasive conditions.

2.12 Inspection and Testing—General

2.12.1 The Applicator's Inspector shall be on site during surface preparation and coating application.

2.12.2 The Applicator shall be responsible for the quality of all their operations.

2.12.3 The Applicator shall provide calibrated test instruments to the Company's onsite Coating Inspector for verification. Calibrate all test instruments on a yearly basis.

2.12.4 Carry out and record all quality control measurements and inspections on a Company-approved form that captures required data. Ensure the records outlined in Table 2-2 are available for review by the Company at all times and submit originals to the Company at the end of the project.

**Table 2-2: Required Physical Testing**

| Test Type | Test Reference | Frequency |
|---|---|---|
| Environmental Conditions & Steel Surface Temperature | See Section 2.2.2 | Start of shift and every 4 hours thereafter (minimum) per crew |
| Visual Inspection of Steel Surfaces for Contaminants | See Section 2.2.1 and 2.2.3 | 100% of all items to be coated |
| Abrasive Contamination Testing (as applicable) | Contact Responsible Engineer | See Section 2.2.8 - 2.2.12 |
| Abrasive Blast Air Blotter Test | ASTM D4285 & Section 2.2.16 | Beginning of each shift |
| Salt Contamination of the Steel Surface | SSPC-Guide 15 & Sections 2.2.4, 2.14 20mg/m² or 3ppm | 1 per 50 Joints for mainline, 1 per 5 joints for tie-in crew. To be conducted by each crew (tie-in and mainline) |
| Visual Exam of Cleaned Steel Surfaces | SSPC VIS 1 and Section 2.2.6 | 100% of all cleaned surfaces for coating |
| Abrasive Blast Profile Measurements | ASTM D4417 | See Section 2.13 |
| Monitor Steel Preheat (if required) | Pre-Heat Section 2.4 | 100% of items coated |
| DFT | Gauge Readings | See Table 2-1 and Section 2.15 |
| Visual Inspection of Application | See Section 2.7.3 | 100% of items coated |
| Holiday Detection | NACE SP0188 & Table 2-5 | 100% of items coated |
| Cure Test Using Shore D Hardness Conducted on the Steel and Existing Coating | See Section 2.16 | 1 set per 25 joints or minimum 1 per day whichever is greater (maximum of 10 hours) it shall be conducted by each crew (Tie-in and mainline)<br>Shop – 2 per shift (maximum of 10 hours) |
| Adhesion Test Using X-Cut<br>Conducted on the Steel and Existing Coating | See Section 2.17 | 1 set per 50 joints or minimum 1 per day whichever is greater (maximum of 10 hours) to be conducted by each crew (tie-in and mainline)<br>Shop – 2 per shift (maximum of 10 hours) |

2.13 Inspection and Testing—Anchor Profile Measurement Frequency

2.13.1 When cleaning single items, conduct the minimum number of readings listed within Table 2-3.

2.13.2 If a trailer load or large shipment of piping, fittings, valves, pipe supports, or multiple pre-fabricated assemblies are to be abrasively cleaned for coating, at the discretion of the Company's onsite Coating Inspector the frequency of profile measurements listed may be changed to four measurements per hour of abrasive blasting. Take blast profile readings at different locations on the items abrasively cleaned. If this process occurs, document it on the Company approved form.

**Table 2-3: Profile Measurement Recordings**

| Object | Size | Minimum Number of Spot Readings |
|---|---|---|
| Pipe | Every 20 linear meters (65 ft.) | 4 randomly spaced along and around the pipe |
| Fittings | Each, less than 20 linear meters (65 ft.) | 4 randomly spaced along and around the fitting |
| Pipe Sections | Each, less than 20 linear meters (65 ft.) | 4 randomly spaced along and around the pipe section |
| Girth Welds and Tie-in Welds | 1 set of 3 readings per 25 joints | 3 per joint in different quadrants of the girth weld or tie-in weld |
| Valves | Each | 3 along and around the valve for ≥ 406 mm (16 in.)<br>2 along and around the valve for < 406 mm (16 in.) |
| Pre-Fabricated Valve Assemblies (all sizes) | Each Assembly | 6 randomly spaced along and around the assembly for ≥ 406 mm (16 in.)<br>4 randomly spaced along and around the assembly for < 406 mm (16 in.) |
| Repair Areas | Surfaces of repair areas exceeding 25 $cm^2$ (4 $in.^2$) | 1 reading every 2nd repair area |

2.14 Inspection and Testing—Salt Testing Frequency

2.14.1 Testing frequencies for non-soluble salt on steel surfaces for new construction or fabrication shall be as follows:

- Line-pipe–test the first three joints at the start of the project, then once every 3 km (1.4 miles). If salt is present, test every joint until at least 10 consecutive joints are salt-free.
- Tie-ins–test the first weld and 25th welds. If no salt is present, no further testing is required unless the Company's onsite Coating Inspector suspects salt contamination or the mainline coating tests positive for salt contamination during production. If salt is present on tie-ins, test every weld until five consecutive tie-in welds are salt free. This is on a per crew basis.
- All other items (e.g., valves, fittings, risers)–test once per item. If a truckload of valves, fittings or assemblies require testing, test twice per truckload.

2.15 Inspection and Testing—DFT Measurement

2.15.1 Measure the DFT with a calibrated thickness gauge. Verify calibration of the gauge at the beginning of the shift or every 10 hrs (whichever comes first) to the National Institute of Standards and Technology (NIST) Certified Coating Thickness Standard, or gauge Manufacturer supplied shims.

2.15.2 After the coating has cured to a tack-free condition, measure, at random, the DFT of each valve, fitting, and pipe section as in accordance with Table 2-4.

**Table 2-4: DFT Measurements Required**

| Object | Size | Minimum Number of Spot Readings |
|---|---|---|
| Pipe | Every 20 linear meters (65 ft.) | 5 randomly spaced along and around the pipe |
| Fittings | Each, less than 20 linear meters (65 ft.) | 5 randomly spaced along and around the fitting |
| Pipe Sections | Each, less than 20 linear meters (65 ft.) | 5 randomly spaced along and around the pipe section |
| Girth Welds and Tie-in Welds | Each | 5 randomly spaced along and around the girth weld or tie-in weld |
| Valves | Each | 4 along and around the valve for ≥ 406 mm (16 in.)<br>2 along and around the valve for < 406 mm (16 in.) |

2.15.3 Use the following criteria when DFT readings are outside of the range specified in each application procedure:

- If one out of five DFT readings is outside of the range specified, perform further testing. The Company may have their onsite Coating Inspector mark with a felt pen a 30 cm x 30 cm (12 in. x 12 in.) area of their choice on the pipe. The Inspector will take 20 random DFT measurements within the marked area. No individual reading shall be less than the specified minimum thickness.
- If coating thickness is below specified DFT, additional coating application must be within the Manufacturer's recoat window. If the sum total of the areas is less than 1 $m^2$ (1550 $in^2$) per item coated, sweep blasting and overcoating may be performed. Deviations require written acceptance from the Responsible Engineer.
- If coating thickness is greater than specified DFT, do not abrade the coating to reduce the thickness to the specified thickness. Remove the coating and recoat.

2.16 Inspection and Testing – Cure Test Using Shore D Hardness

2.16.1 The Contractor's Coating Inspector and/or the Company's onsite Coating Inspector shall conduct this test on girth welds, tie-in welds, pipe, or pipe assemblies. Note: for shop spray applications, it is acceptable that Shore D testing can be conducted on panels that are prepared, applied and cured in the same manner as the items coated during production.

2.16.2 Conduct the Shore D test when the coating has completely cured as determined by the Applicator's Coating Inspector. Conduct testing as follows:

- Start out at a spot where the coating DFT is measured at 765µm (30 mils) minimum.
- Test between 10°C and 25°C (50°F and 77°F) after the coating has reached a thumbnail hard state. Coating is sufficiently cured for handling or backfilling if a minimum Shore D hardness rating of 80 is obtained.
- If Shore D hardness is measured on the overlap area, the total thickness of the coating shall be at least 765µm (30 mils) greater than the thickness of the underlying overlapped coating.
- Frequency of testing is in accordance with Table 2-2.

  Note: For projects in hotter geographical locations or warmer summer ambient temperatures, the target range of 10 to 25°C for Shore D testing may not be achievable. Contact the Responsible Coatings Engineer for guidance.

2.17 Inspection and Testing—Adhesion Test Using X-cut

2.17.1 Conduct X-cut adhesion testing on coating applied to the steel surface and on the overlap area between existing and newly applied coatings (e.g., liquid epoxy overlapping onto FBE coated line pipe). The Contractor's Coating Inspector and/or the Company's onsite Coating Inspector shall conduct this test on girth welds, tie-in welds, pipe, or pipe assemblies. Note: for shop spray applications, it is acceptable that X-cut adhesion testing can be conducted on panels that are prepared, applied and cured in the same manner as the items coated during production.

2.17.2 Conduct the X-cut adhesion test when the coating has completely cured as determined by the Applicator's Coating Inspector. Conduct testing as follows:

- Test when the exterior coating temperature is between 10°C and 25°C (50°F and 95°F) after the coating is considered cured.
- Frequency of testing is in accordance with Table 2-2.

Note: For projects in hotter geographical locations or warmer summer ambient temperatures, the target range of 10 to 25°C for X-cut adhesion testing may not be achievable. Contact the Responsible Coatings Engineer for guidance.

2.18 Inspection and Testing—Holiday Detection

2.18.1 Carry out holiday detection in accordance with NACE SP0188. Set voltages as described in Table 2-5. Calculate voltages based on the average coating DFT.

**Table 2-5: Required Holiday Detection Voltage Ranges**

| Coated Item | Calculation Formula | Holiday Detection Voltage (VDC) |
|---|---|---|
| Girth Welds & Tie-In Welds | 4 V/µm (100 V/mil) | 2,000 – 7,000 |
| Abrasion Resistant (ABR) Girth Welds | 4 V/µm (100 V/mil) | 4,000 – 7,000 |
| Abrasion Resistant Overcoated Pipe with Liquid Coating | 4 V/µm (100 V/mil) | 4,000 – 7,000 |
| Fusion Bonded Epoxy FBE System 1A | 5 V/µm (125 V/mil) | 2,000 – 5,000 |
| Fusion Bonded Epoxy FBE ABR System 2B | 5 V/µm (125 V/mil) | 4,300 – 5,000 |
| Repairs to FBE or liquid applied coatings | 4 V/µm (100V/mil) | 2,000 – 7,000 |

2.18.2 Inspect completed coating repairs for holidays as specified in Table 2-5.

2.18.3 Use a spring encirclement or half-moon type search electrode to holiday detect pipe sections. Holiday detect girth welds with spring encirclement or a brass brush electrode. To ensure that no holidays are missed, bring the spring encirclement electrode back to the downstream side of the toe of the weld inspected. Use a brass brush electrode to reach the bottom of corrosion pits.

2.18.4 Calibrate holiday detectors using a calibrated voltmeter at the start of the working day and at least every four hours or as specified by the Company.

2.18.5 Keep calibration certifications for the holiday detection equipment and voltmeter with the equipment.

2.18.6 At the discretion of the Company, make an intentional holiday in the coating to bare steel to verify that the holiday is detected at the appropriate voltage for the coating application. If the voltage is not adequate, increase the voltage until the intentional holiday is detected, but do not exceed 7,000V.

2.18.7 Keep the coating surface dry and free of deposits (e.g., soil, ice, snow, or tape) when holiday testing is conducted. Markings on the coating surface having no measurable thickness are allowed when holiday testing.

2.18.8 A low voltage (60 to 70V) wet sponge holiday detector may be used on nuts and bolts and areas difficult to access. Do not damage adjacent coating with a lower DFT.

2.18.9 Do not attempt inspection with a holiday detector until the coating is hard dry (hard dry as determined when the coating does not indent when pressed with a thumbnail).

## 3 VARIANCES

Any deviation shall follow the TransCanada Management of Change (MOC) Variance Procedure (EDMS No. 7728702). External vendors must contact the TransCanada Project Engineer for variance approval.

## 4 ROLES AND RESPONSIBILITIES

Table 4-1 below outlines the roles and responsibilities required for the use of this Specification.

**Table 4-1: Roles and Responsibilities**

| Role | Responsibilities |
|---|---|
| Applicator | The Applicator is responsible for ensuring:<br>• The proper method is used to apply the appropriate coating materials to the appropriate surface area. |
| Coating Inspector | The Coating Inspector is responsible for ensuring:<br>• That the Applicator uses the proper method to apply the coating materials to the appropriate surface area, and that the result meets the standards set forth by the Company in this specification. |
| Responsible Engineer | The Responsible Engineer is accountable for ensuring:<br>• That the plan set forth by the applicator meets the standards set forth by the Company, and that resolution to any questions that arise from the use of this specification meet the standards set forth by the Company. |
| Manufacturer | The Manufacturer is responsible for ensuring:<br>• That the product produced for application is produced in accordance with the documentation that it provides to the Applicator. |

## 5 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are detailed below in Table 5-1. Use the latest document revision, unless otherwise approved by TransCanada.

**Table 5-1: External and Internal References**

| Document No. | Title |
|---|---|
| **Legal Requirements** | |
| For this Specification, there are no specific legal requirements. | |
| **Industry Codes and Standards** | |
| CSA Z245.30 | Field-applied external coatings for steel pipeline systems (Canada only) |
| ISO 9001 | International Standards Organization - Quality Management Standard Certifications |
| NACE SP0188 | Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates. |
| SSPC SP-1 | Solvent Cleaning |

| Document No. | Title |
|---|---|
| SSPC SP-10 | NACE No. 2/SSPC-SP 10, Near-White Metal Blast Cleaning |
| ASTM D4285 | Standard Test Method for Indicating Oil or Water in Compressed Air |
| **Internal References – Documents Referenced by this Specification** | |
| EDMS No. 3670892 | TES-COAT-FBE External Fusion Bond Epoxy for Steel Pipe Specification (CDN-US-MEX) |
| EDMS No. 7756 | TES-COAT-PET Application of Petrolatum Tape Coating Specification (CDN-US-MEX) |

## 6 DOCUMENTATION AND RECORDKEEPING

All project documentation is held in the project file and stored in accordance with the Company's guidelines.

## 7 DOCUMENT HISTORY

| Rev. | | |
|---|---|---|
| 13 | **Description** | **Effective Date** |
| | This document is the new version of TES-COAT-EPU, updated in accordance with the documentation Streamlining initiative. | 2016-Nov-08 |
| | **Rationale Statement** | **Responsible Engineer** |
| | of content to reflect the updated document collection of the coatings This document was developed / revised in order to address the following requirements:<br>• Streamlining department | Aissa Van Der Veen<br>P. Eng. |
| | **Impact Assessment Summary** | **Document Owner** |
| | This Specification was revised to streamline the documentation required for the Coatings group and to make it more easily accessible to those who use it. | Aissa Van Der Veen<br>P. Eng. |

## 8 DESCRIPTION OF CHANGE

| Section | Description of Change |
|---|---|
| **Regulatory** | |
| N/A | N/A |
| Industry Standards | |
| N/A | N/A |
| General | |
| Update to format and content | Part of Streamlining and Simplification process, document has been reformatted and updated to reflect TransCanada template |

## 9 APPROVALS

| APPROVALS | | |
|---|---|---|
| Originator:<br>Aissa Van Der Veen, P. Eng.<br>Welding and Materials Engineering | Signature | Date: Nov. 8, 2016 |
| Reviewer:<br>Niteesha Falcon, P. Eng.<br>Welding and Materials Engineering | Signature: Niteesha Falcon | Date: Nov 8, 2016 |
| Responsible Engineer:<br>Aissa Van Der Veen, P. Eng.<br>Welding and Materials Engineering | Signature<br>Date: Nov. 8, 2016 | PROFESSIONAL ENGINEER ALBERTA AISSA VAN DER VEEN<br>APEGA Permit to Practice P7100 |

# APPENDIX A INSTRUCTIONS FOR ITEMS TO BE COATED

## A-1 COATING OF VALVES AND FITTINGS

A-1-1 The coating material for valves and fittings shall be spray grade liquid coating in accordance with this Specification. Use brush grade liquid coating on difficult areas.

A-1-2 The crotch area, including the outlet portion, of all tees with a nominal run diameter greater than NPS 16 and run diameter to outlet diameter ratio in excess of 0.6 shall not be coated with any liquid coatings until after secondary hydrostatic testing has been completed to avoid cracking of the coating. Coating applications may proceed prior to secondary hydrostatic testing providing the items remain exposed (not backfilled), so the coating can be inspected after the secondary hydrostatic test for cracking and disbondment from the steel surface. The Applicator shall check with the Project to determine if any items to be coated shall be left bare until after secondary hydrostatic testing due to commitments to regulatory bodies.

A-1-3 Do not apply direct heat to the valve assembly during coating. It is recommended that valves be coated in an enclosure or indoors. Maintain a minimum surface temperature of 10°C (50°F) until four hours after the coating is tack free.

A-1-4 Valves may not be post heated except by increasing ambient air temperature.

A-1-5 The coating cutback on liquid coating applied to new piping shall be 10.5 cm (4 in.), unless specified elsewhere (e.g., purchase order).

## A-2 COATING OF GIRTH WELDS

A-2-1 Coating material for girth welds shall be brush grade and shall be applied according to this Specification. The use of spray grade coating material for girth welds may be permitted when applied by automated spray systems. Hand-held spray is not permitted for girth weld coating.

## A-3 COATING OF STRUCTURAL STEEL

A-3-1 The coating material for structural steel to be buried, such as below ground pipe supports, shall be spray or brush grade and shall be applied according to this Specification. Piles do not require below ground coating (above grade piles do require painting as per TES-COAT-P1). Any below ground pipe supports fabricated or installed in the field shall be entirely coated (tops, sides and bottom). The pipe supports shall be coated with an approved material listed in Table 2-1 of this Specification. Holiday testing of structural steel is not required.

## APPENDIX B CSA Z245.30-14 REQUIREMENTS (CANADIAN PROJECTS)

This Company Specification shall comply with the requirements of Canadian Standards Association (CSA) Standard Z662 and CSA Z245.30-14 and any amendment, supplement, or errata issued by CSA for use on projects in Canada.

The coating, application process, and resulting coating system shall meet the requirements of CSA Z245.30-14, this Specification (and its associated applications procedures), and the Manufacturer's Qualified Application Procedure (MQAP). Use this Specification for Canadian projects in conjunction with CSA Z662 and CSA Z245.30-14 and any amendment, supplement, or errata issued by CSA. The numbering of Clauses in this Appendix corresponds to the numbering in CSA Z245.30-14. Clauses in this Appendix that are in addition to CSA Z245.30-14 are numbered sequentially.

The Manufacturer's MQAP for the use of their product shall be considered an integral part of this Specification. A list of all Company approved MQAPs is available through the Responsible Engineer. Only MQAPs on this list shall be used for coating systems listed in CSA Z245.30 defined as FC1, FC2 and FC3.

Note: In the event of a conflict between the Manufacturer's recommendations and this Specification, this Specification shall prevail. In this Specification and Appendices, when a Company Specification or Procedure is listed, it is implied that the application shall be in accordance with the MQAP and the listed Company Specification.

### 2 Reference publications

The applicator shall gather all reference documents listed in CSA Z245.30-14 and the reference documents listed in this specification on site where the coating application is taking place and be available to the Company onsite Coating Inspector for review and acceptance.

### 5 Materials

### 5.1 Product ordering

5.1.3 All Manufacturer and Company approved coating MQAPs are available through the Responsible Engineer. The MQAP to be applied shall be added to the purchase order.

### 5.2 General

a)The Applicator shall request the certificate of material qualification from the Manufacturer for each shipment of coating received on site or at a shop location. This certificate shall be added to the turnover package.

### 5.3 Qualification

5.3.4.1 The Manufacturer shall inform the Company Responsible Engineer when there is a change in one or more of the following:

a) The coating chemical formulation;

b) The location of manufacture;

c) The manufacturing process; and

d) The application procedure (MQAP)

**6 Coating application**

**6.1.2 Qualification of applicators**

6.1.2.1 h) The Manufacturer shall be present during applicator training of the MQAP prior to start of work, unless a train-the-trainer program has been approved by the Company.

6.1.2.3 The Applicator shall inform the Company when all aspects of Applicator training and qualification testing are being conducted. The Company's onsite Coating Inspector shall make all attempts to witness the training and qualification testing.

**6.1.2.5 Certificate of applicator qualification**

Copies of all certificates of Applicator qualification shall be provided to the Company's onsite Coating Inspector.

**6.1.3.2 Experience logs**

Applicator's experience logs shall be reviewed by the Company's onsite Coating Inspector to ensure the Applicator is qualified to the MQAP being used on the project.

**6.1.3.3 Competency determination**

6.1.3.3.3 The Company shall review the Application company's competency determination and make its own determination based on the requirements of Clause 6.1.3.3.1.

**6.1.3.4 Competency records**

Copies of competency determination and retests shall be provided to the Company's onsite Coating Inspector.

**6.2 Application practices and equipment**

**6.2.3 Surface temperatures**

6.2.3.4 Substrate temperature and curing temperatures to be used shall be in accordance with the MQAP and TES-COAT-EPU.

**6.2.4 Applying the coating system**

6.2.4.1 The application of the coating shall be in accordance with the MQAP and TES-COAT-EPU.

**6.3 Records**

6.3.1 All quality control measurements and inspections shall be carried out and recorded by the Applicator or Company personnel on the appropriate form.

**7 Inspection and testing**

**7.1 Inspection and test plan**

j) List Specification clause numbers for each line item on the ITP where applicable.

**9 Markings**

9.1 The Applicator shall mark the date of application and the name of/or a unique identifier for the applicator on, or adjacent to, the applied coating.

## 11 Applied coating test reports and certificates of application compliance

### 11.1 Test reports

The Applicator's records, as outlined in Table 2-2 of this Specification and Table 6 of CSA Z45.30-14 shall be available for review by the Company at all times and copies shall be submitted to the Company's onsite Coating Inspector. The Company shall retain the original copies of the coating reports.

### 11.2 Certificates of application compliance

The Applicator shall provide the Company, at the end of the project, with certificates of application compliance stating the outlined items in Clause 11.2 of CSA Z245.30-14.

## PURPOSE

This Specification defines the minimum requirements for the surface preparation, application of paint, repairs and inspection of paint materials for above ground gas and hazardous liquid facilities and equipment for new construction and integrity related projects for coastal and non-coastal areas.

## SCOPE/APPLICABILITY

This Specification applies to all gas and hazardous liquid pipeline systems in Canada, the United States (U.S.) and Mexico, and includes facilities such as miscellaneous steelwork, piping and piping components, vessels and equipment. It applies to both shop and field work under a full range of operating conditions.

This Specification does not apply to the following items:

- battery chargers
- utility air compressors (including desiccant dryers)
- reciprocating motors/compressors
- gas turbine and driven equipment
- exhaust silencers
- start gas vent silencers
- actuators/operators and their associated equipment
- heat exchanger header boxes for engine jacket water coolers
- unit heaters
- engine jacket water coolers
- transportable oil storage tanks
- small tanks for compression and measurement
- valves NPS 14 and smaller
- concrete
- low pressure piping (< 2000 kPa) (< 290 psi)
- structural steel and piles (where a corrosion allowance has been included)

**Note:**

This list is not comprehensive. Contact the Responsible Engineer for a list of all items that may be painted by the Manufacturer or that may fall outside of the scope of this Specification. This list is at the discretion of the Project.

All Applicators applying above ground paint materials in accordance with this Specification shall be Company-approved Applicators.

This Specification applies to all divisions of the Company and its wholly-owned subsidiaries, and all operated entities/facilities in Canada, the United States (U.S.) and Mexico.

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

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

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# 1 GLOSSARY

**Applicator**

The company responsible for the actual application of the paint.

**Company Coating Inspector**

A designated onsite coating inspector hired by the Company for the duration of the Project.

**DFT**

Dry Film Thickness. The thickness of the paint after it has hardened to a solid state, as defined in The Society for Protective Coatings (SSPC)-PA 2 *Procedure for Determining Conformance to Dry Coatings Thickness*.

**Manufacturer**

A company that manufactures and supplies the paint system.

**Pre-fabricated valve assemblies**

Assemblies that have been bolted or welded together, such as pipe pups, valves, elbows, check valves and flanged items that are already fabricated prior to painting and are to be installed as one piece into the facility being constructed.

**Structural steel**

Steel I beams and piles, not including pipe supports or pipe saddles.

**Vendor**

Any outside source hired by the Company to complete work.

**WFT**

Wet Film Thickness. The thickness of the paint film while in the liquid state.

# 2 REQUIREMENTS

## 2.1 General Requirements

2.1.1 The Applicator is responsible to adhere to the requirements outlined in this Specification.

2.1.2 The Applicator shall have Safety Datasheets (SDS) for all controlled products and shall ensure that its employees (i.e., sub-contractors or agents) are familiar with the instructions of the SDS.

2.1.3 The SDSs shall be available on site for review by the Applicator's personnel and the Company Coating Inspector.

2.1.4 The Applicator shall provide at least one National Association of Corrosion Engineers (NACE)-certified CIP Level I at their shop or field location. This employee shall perform inspections, supervise other employees conducting inspections and be experienced and competent in the application of above ground paints. An alternatively trained employee may be considered acceptable upon review and approval by the Responsible Engineer.

## 2.2 General Requirements—Compliance

2.2.1 All work shall be done in accordance with the Manufacturer's recommendations, product datasheets, application procedure and this Specification.

2.2.2 All quality control measurements and inspections shall be carried out and recorded by the Application company or Company personnel.

2.2.3 For applications outside of Canada, the U.S. and Mexico, contact the Manufacturer and confirm in writing that the paint products are the same paint product listed in this Specification, as there may be changes in the Manufacturer's Technical Datasheets (TDS) between locations. Provide the information to the Company's onsite Coatings Inspector or Responsible Engineer.

2.2.4 Personal protective equipment (PPE) shall be used while abrasive blasting. This shall include proper clothing, hearing protection, safety boots, gloves and a ventilated blast hood to protect the face and prevent inhalation of abrasive blasting dust. The blast hood shall be fed with air that is pressure regulated, filtered and meets regulatory requirements.

2.2.5 Abrasive blast cleaning equipment shall be fitted with a functional dead man remote control system. Abrasive blast hose couplings shall be secured with safety wire and chokers. All mechanical equipment, including blasting equipment, shall be earthed and all precautions taken to prevent the build-up of static electricity.

2.2.6 Paints and solvents should only be used in well-ventilated areas and personnel shall wear the appropriate respiratory protection as required by the Manufacturer.

2.2.7 During paint application, no open flames, smoking, grinding or welding shall be allowed in the immediate vicinity.

2.2.8 Under no circumstances shall any paint be removed by heating with an open flame.

## 2.3 General Requirements—Quality

2.3.1 The Applicator shall have at least one of the following with regards to a quality program:

- a current registration as a Society for Protective Coatings (SSPC) QP 1 (Field Application to Complex Industrial and Marine Structures) and as an SSPC QP 3 (Shop Painting Certification Program)
- NACE NIICAP AS-1 *Program for Accreditation of Field and Shop Coatings Contractor* accreditation
- a certificate of compliance with International Organization for Standardization (ISO) 9001 *Quality Management Systems – Requirements*
- a documented Company Quality Management System

2.3.2 Company personnel applying paint materials shall read and understand this Specification and the TDS before commencing painting operations. Company personnel wanting to spray apply above grade paint materials shall contact the Responsible Engineer for approval.

2.3.3 An Inspection and Test Plan (ITP) for the supply and application of paint materials shall be submitted for approval to the Company Coating Inspector or Responsible Engineer prior to the commencement of work.

## 2.4 Materials—Paint Material Selection

2.4.1 Paint materials shall be:

- selected according to the paint system requirements outlined in APPENDIX A and APPENDIX B, based on the atmospheric zones (ISO 12944 *Paints and varnishes – Corrosion protection of steel structures by protective paint services*, corrosivity category) described in Table 2-1
- from the same Manufacturer for multi-coat systems (i.e., primer and topcoat system)

**Table 2-1: ISO Corrosivity Category Based on Environment**

| ISO Corrosivity Category | Environment |
|---|---|
| C1 and C2 | Heated buildings/neutral atmosphere, rural areas, low pollution |
| C3 | Urban and industrial atmospheres with moderate sulphur dioxide levels, production areas with high humidity |
| C4 | Industrial and coastal areas with moderate salinity, chemical processing plants |

2.4.2 The material for each coat shall be from the same Manufacturer in multi-coat systems.

2.4.3 Each coat shall be a different colour or shade so that successive coats can be distinguished.

2.4.4 Topcoat paint options include polyurethane and polysiloxane products. The attributes of these products are detailed in Table 2-2. The Project shall decide which attributes are required.

**Table 2-2: Topcoat Appearance Attributes**

| Material | Pros | Cons | Suggested Use |
|---|---|---|---|
| Polysiloxanes | • Better gloss retention<br>• Longer lasting colours | • More expensive than Polyurethanes<br>• Longer cure times | • Facilities in high traffic areas may choose the polysiloxane finish due to high visibility |
| Polyurethanes | • Less expensive than Polysiloxanes<br>• Quality of the paint system and the facility's integrity is not compromised by faded colours<br>• Cures faster, better shop output of completed items | • Colours fade more quickly | • Facilities located in remote areas may choose the polyurethane option due to low visibility |

2.4.5 Alternative materials may be considered if approved in advance by the Responsible Engineer. The proposed Manufacturer's TDS and all testing data performed on the paint product (Manufacturer or third party testing results) shall be included in the request for approval.

2.4.6 For bolts and pipe saddles, electroless nickel coating (ENC) may be used as an alternative material. The ENC may be painted if required. Contact the Responsible Engineer if the ENC is to be used.

## 2.5 Materials—Packaging and Storage

2.5.1 Paint materials shall be delivered to the Applicator in the Manufacturer's unopened, original containers and stored in accordance with the Manufacturer's latest published instructions.

2.5.2 Paint materials shall be applied within their recommended shelf life, otherwise re-certification shall be obtained from the Manufacturer in writing.

2.5.3 Containers of paint or components shall only be opened if they will be used immediately.

2.5.4 Containers shall be identified with the Manufacturer's name, product description, batch number, date of manufacture and expiry date.

## 2.6 Application—Surface Preparation

2.6.1 All nearby equipment and machinery shall be protected from abrasives, dust and overspray. The following surfaces are not to be painted unless otherwise specified by the Project, and must be protected while blasting and painting (spraying) other surfaces:

- machined surfaces such as flange faces
- Manufacturer's name and data plates
- brick, masonry or concrete
- exposed stainless steel (including stainless steel valves), copper, brass and aluminum
- galvanized surfaces
- glass, porcelain and plastics
- valve stems, glands, control valve positioners and gauges
- aluminum sheathing over insulation and weatherproofing
- switchgear, motor control centers and transformers
- items that have a special finish applied by the Manufacturer (e.g., gas engines, generators, compressors, etc.)

2.6.2 If the Applicator is unsure whether an item is to be blasted or painted, the Applicator shall request clarification from the Company Coating Inspector before proceeding with surface preparation activities.

2.6.3 For field applications, the pipe shall be heated to remove any forms of moisture (e.g., ice, snow, wet surfaces, etc.) before surface preparation activities commence.

2.6.4 Prior to abrasive cleaning steel surfaces, all visible burrs, slivers, scabs and weld spatter shall be removed. All rough edges shall be ground smooth and all contaminants (i.e., dirt or water-soluble salts) shall be removed by washing and rinsing with clean water.

2.6.5 Oil, grease or other foreign material shall be solvent cleaned in accordance with SSPC-SP 1 *Solvent Cleaning*.

2.6.6 Applicators shall verify that the surfaces are not contaminated with detrimental levels of non-visible soluble salts. Chloride levels shall be less than or equal to 20 $mg/m^2$ (conversions to ppm shall follow the instructions in the salt test kit manual). Salt testing shall be done prior to blast cleaning as per the frequencies listed in Table 2-3 of this Specification. Chlorides shall be removed using distilled water and repeat salt testing. This shall be continued until chlorides are within acceptable levels.

2.6.7 The ambient conditions, surface temperature, dew point and relative humidity shall be monitored and recorded at the beginning of each shift and every four (4) hours thereafter. If ambient conditions change, additional measurements shall be taken.

2.6.8 During abrasive blast cleaning and until priming, the surface shall be dry and the surface temperature shall be at least 3C° (5F°) above the dew point temperature.

2.6.9 The pipe surface temperature shall be measured using a surface contact thermometer. The temperature shall be maintained within the Manufacturer's recommended range.

2.6.10 One of the following Company-approved abrasives shall be used:

- Green Diamond
- Black Beauty
- Black Magic
- Starblast XL
- Black Shot II
- Black Lightning

A Company-approved equivalent may be used in lieu of the abrasives listed above. Contact the Responsible Engineer for approval of alternative equivalent abrasives. The use of reclaimed/recycled blast cleaning abrasives is not permitted except where metallic grit is employed in automatic centrifugal cleaning machines, or where blasting enclosures have been approved by the Company. Copper-bearing abrasives and steel shot shall not be used.

2.6.11 The abrasive blast media shall be dry and shall contain no contaminants injurious to the performance of the paint.

2.6.12 If Company approved abrasives are used, soluble salt or oil contamination testing on the abrasive is not required provided the abrasives are packaged and stored in accordance with the Manufacturer's recommendations. If the Company Coating Inspector suspects the abrasive being used is contaminated or is not listed in the approved abrasive list, testing of the abrasive is required.

2.6.13 If an alternative equivalent abrasive is used, soluble salt or oil contamination testing shall be conducted daily. Bulk orders of abrasive shall be tested once per load to confirm that each shipment of abrasive does not contain soluble salts or oil contamination.

2.6.14 Chloride testing shall be conducted as follows:

1. A sample of at least 100 mL (3.38 fl. oz.) of abrasive is mixed with an equal volume of distilled water in a clean transparent container.
2. The mixture is agitated for at least thirty (30) seconds. The abrasive is then allowed to settle to the bottom of the container.
3. The chloride content during testing shall not exceed 3 ppm (3 mg/L) and no oil shall be present when visually examined after remaining in the distilled water for 30 minutes.

2.6.15 The compressed air supply used for blast cleaning or conventional spraying shall be free of water and oil. Separators and filters shall be used on the compressed air supply to ensure that contaminants such as oil and water do not contaminate the steel surface. A blotter test shall be performed in accordance with ASTM D4285 *Standard Test Method for Indicating Oil or Water in Compressed Air* at the start of every working day to verify the cleanliness of the compressed air. Daily blotter tests shall be verified by the Company Coating Inspector for acceptability.

2.6.16 Any abrasive blasting unit or compressed air used for conventional spraying that fails testing shall be re-tested. If the second test fails, the unit shall be taken out of service until it is repaired and can pass the blotter test.

2.6.17 Steel surfaces intended for non-coastal environments shall be abrasive blasted to the cleanliness specified in APPENDIX A of this Specification.

2.6.18 Steel surfaces intended for coastal environments shall be abrasive blasted to the minimum cleanliness specified in SSPC-SP 10/NACE No. 2 *Near-White Blast Cleaning*.

2.6.19 The anchor profile shall be measured and recorded using replica tape and a spring micrometer in accordance with NACE SP0287 *Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape*. The frequency and number of readings shall be per section 2.10 and Table 2-4 of this Specification.

2.6.20 The anchor profile depth of blast-cleaned steel shall be in accordance with the TDS. If no anchor profile recommendations are provided by the TDS, request them in writing from the Manufacturer.

2.6.21 Areas that develop flash rust due to exposure to rain, moisture or humidity shall be given a sweep blast to return them to their original abrasive blast cleaned condition.

2.6.22 The abrasive cleaned surface shall be coated immediately. A sweep blast shall be carried out when an abrasive blasted surface is left overnight.

2.6.23 In shop applications that are climate controlled, abrasive cleaned surfaces may be left overnight prior to coating provided that the Company Coating Inspector reviews the cleaned steel surface to ensure that the required surface cleanliness has been maintained.

2.6.24 Power tool cleaning may be used as an alternative to abrasive blast cleaning for touch-up paint repairs and in certain field applications where abrasive blasting is not permitted due to hazards to the surrounding equipment or personnel. Written approval must be requested from the Company Coating Inspector in areas where abrasive blast cleaning is not permitted. Personnel completing the power tool clean shall demonstrate knowledge of proper use of the equipment to the Company Coating Inspector for acceptance. Power tool cleaning shall be to the SSPC-SP 15 *Commercial Grade Power Tool Cleaning* standard with a minimum anchor profile of 1.5 mils.

**Note:**

For any surface preparation tools, Operators shall provide proof of training or demonstrate knowledge of proper use of the tool to the Company Coating Inspector for acceptance. The MONTI Bristle Blaster is the preferred method of preparing bare areas. The surface shall be cleaned in accordance with SSPC-SP 15 if the MONTI tool is used.

2.6.25 Residual abrasive blast products shall be removed from the entire abrasive blasted surface using a dry and clean bristle brush, a vacuum or clean and dry compressed air.

2.6.26 Surface preparation may be subject to inspection by the Company Coating Inspector, at his or her discretion, before the paint is applied. The Company Coating Inspector shall be provided with reasonable advance notification of the expected time that the blasted surface will be ready for inspection.

2.6.27 Crevices, holes or other surfaces that cannot be accessed properly for painting shall be filled with a suitable caulking material. If the caulking material is applied prior to painting, the Manufacturer shall confirm in writing that the caulking material is compatible with the painting material.

## 2.7 Application—Paint Application

2.7.1 The Manufacturer's application recommendations with respect to mixing, thinning, temperatures and curing shall be followed. In the event of a conflict between the Manufacturer's recommendations and this Specification, the more stringent requirement shall govern.

2.7.2 The paint shall be spray applied in accordance with the paint Manufacturer's instructions. The spray equipment shall be as recommended by the Manufacturer for each specific paint system.

2.7.3 Paints may be brush applied if spray equipment is not available and if the paint Manufacturer's TDS allows paints to be applied in this manner. Brush applications should be limited to two (2) linear meters (6.5 ft.) in length. Brush application is acceptable if the scope of the project is strictly onsite girth welds. Brush application may also be used for repairs and touch ups. An Applicator using the brush method does not need to be pre-qualified by the Company, but should demonstrate the following to the Company Coating Inspector:

- They can brush apply the chosen paint system to the required dry film thickness (DFT).
- The applied paint system is aesthetically pleasing.

If longer sections are required to be brush applied, the Company Coating Inspector shall be consulted for review prior to acceptance.

2.7.4 For projects conducting all fabrication and painting on site, the Project may decide that areas of the pipe in contact with pipe supports require coating as per *TES-CO-EPU-GL Field-Applied External Liquid Coating Systems for Steel Pipes Specification*

*(CAN-US-MEX)* (EDMS No. 3671710). When required by a project, the Applicator shall apply liquid coating to a DFT of 1,020 µm to 1,780 µm (40 mils to 70 mils) around the circumference of the pipe in accordance with *TES-CO-EPU-GL*. The liquid coating shall extend a minimum of 150 mm (6 in.) beyond where the pipe support comes into contact with the piping. Once the liquid coating is cured, the surface shall be roughened by brush blasting, and a UV-resistant topcoat shall be applied as per this Specification. Contact the Responsible Engineer if further clarification is required.

2.7.5 A cutback of 10.2 cm (4 in.) shall be left adjacent to any area to be welded after painting.

2.7.6 The following areas shall be stripe painted, as they are challenging to paint and to ensure paint coverage and thickness requirements are met:

- boltholes
- bolts
- sharp edges
- flanges
- rough welds
- other areas with significant geometry

2.7.7 If an item to be painted has already been coated with an external liquid coating or a fusion bond epoxy (FBE) coating, the existing coating shall be roughened to remove gloss and an anchor profile shall be provided, followed by a topcoat. The topcoat shall be applied in accordance with this Specification. When transitioning from above ground to below ground, refer to of APPENDIX C.

2.7.8 Paint materials containing zinc must be sprayed from continuously agitated pots. The topcoat must be applied in a mist coat before applying a full coat to avoid blistering and craters. Consult the Manufacturer's TDS for information on overcoating inorganic zinc.

2.7.9 If the pot life of the paint material is exceeded, the material shall be discarded, the equipment shall be cleaned and new material shall be prepared.

2.7.10 Inorganic zinc primers shall pass the ASTM D4752 MEK test for cure before being topcoated. With permission from the Company Coating Inspector, a coin rub test may be performed instead.

2.7.11 The Applicator shall test the wet film thickness (WFT) of each coat (except the ethyl silicate zinc primer, as the zinc may provide a false reading) during application with a WFT gauge.

2.7.12 The DFT for each coat shall be measured and recorded for its specified range using a calibrated magnetic thickness gauge in accordance with SSPC-PA 2 *Procedure for Determining Conformance to Dry Coatings Thickness*.

2.7.13 The thickness gauge shall be calibrated once per shift or every 10 hrs (whichever comes first) to a National Institute of Standards and Technology (NIST) *Certified Coating Thickness Standard*, or gauge Manufacturer supplied shims.

2.7.14 The minimum DFT for the primer, intermediate coat and topcoat shall be in accordance with Appendix Table A-1 and Appendix Table B-1. Multiple coats may be required to achieve the minimum DFT for each layer. Refer to the applicable Manufacturer's painting procedure for the minimum and maximum DFT per coat.

2.7.15 Some primers listed within this Specification, specifically inorganic zincs, are film thickness sensitive, and cracking may occur if applied too thick. These primers shall be applied in accordance with the thicknesses specified in the applicable TDS. Inorganic zincs (paint code P7) can be found in Appendix Table A-2.

2.7.16 The cured paint shall be visually inspected for film defects. The following defects are not acceptable and require repair at the Applicator's expense:

- runs
- sags
- embedded debris
- voids
- overspray
- mud cracking
- inadequate cure
- lack of adhesion

2.7.17 Tees shall not be painted until after they have been hydrotested to avoid damage to the paint system. In the event that tees are painted prior to the hydrotest, inspect the crotch areas of the tees to ensure no damage has occurred to the applied paint system after the hydrotest. If damage to the paint system occurs, repairs shall be conducted in accordance with this Specification.

2.7.18 Above ground flanges on the Columbia Pipeline Group (CPG) system shall be filled and wrapped as per the application procedure in APPENDIX D.

## 2.8 Application—Repairs

2.8.1 Before applying the next coat, the underlying paints shall be examined for damaged and/or contaminated areas. The following repairs shall be performed where required:

- For repairs up to 2 mm (1/16 in.) in diameter, roughen the surface of the parent coating to remove gloss around the holiday to a distance of at least 25 mm (1 in.). Use 80 grit to 120 grit sandpaper or light sweep blasting.
- For repair areas less than or equal to 25 $cm^2$ (4 $in.^2$), blast clean the affected areas to the applicable standard or hand or power tool clean in accordance with SSPC-SP 15 *Commercial Grade Power Tool Cleaning*.

- For repair areas exceeding 25 $cm^2$ (4 $in.^2$), abrasive blast clean in accordance with section 2.6 of this Specification.
- Feather out the edges.
- Solvent clean dirt, loose deposits, oil and grease in accordance with SSPC-SP 1 *Solvent Cleaning* using solvents that will not have a deleterious effect on the primer.
- Remove salts with clean water by brush or power washing.
- After surface preparation, apply primer to areas requiring touch-up and allow to cure prior to application of the next coat.
- Ensure abraded and repaired areas overlap the underlying coating by a minimum of 25 mm (1 in.).

2.8.2 Limit brush and roller application of inorganic zinc primers to small repair areas unless the paint Manufacturer's TDS states brush and roller applications are an acceptable method of application.

## 2.9 Inspection and Testing—General

2.9.1 The Applicator's Inspector shall be on site during the surface preparation and painting application.

2.9.2 The Applicator shall be responsible for the quality of all of their operations, which shall be controlled and maintained by periodic inspection and testing.

2.9.3 The Applicator shall provide all calibrated test instruments' calibration records to the Company Coating Inspector for verification. All test instruments shall be calibrated on a yearly basis.

2.9.4 All quality control (QC) measurements and inspections shall be done by the Applicator and recorded. Applicators may use the Company form *TEF-CO-PAINT-GL Coating Inspection Form for: Above Ground Painting (CAN-US-MEX)* (EDMS No. 5880500).The records for items in Table 2-3 shall be available for review by the Company at all times and the Applicator shall submit originals to the Company at the end of the Project.

**Table 2-3: QC Testing**

| Test Type | Test Reference | Frequency |
|---|---|---|
| Environmental conditions and steel surface temperature | Sections 2.6.7, and 2.6.8 | Start of shift and every 4 hours thereafter (minimum) |
| Visual inspection of steel surfaces for contaminates | Section 2.6.4 | All items to be coated |
| Abrasive contamination testing (as applicable) | Contact the Responsible Engineer, section 2.6.14 | Sections 2.6.12 and 2.6.13 |

| Test Type | Test Reference | Frequency |
|---|---|---|
| Abrasive blast air blotter test | ASTM D4285, sections 2.6.15 and 2.6.16 | Beginning of each shift (sections 2.6.15 and 2.6.16) |
| Visual exam of cleaned steel surfaces | SSPC-VIS 1, SSPC-SP 10, sections 2.6.5 | All items cleaned |
| Salt contamination of the steel surface | SSPC Technology Guide 15, section 2.6.6 | Test for soluble salt once per shift (maximum of 10 hours between tests). If a truckload of items requires testing, test twice per truckload. For integrity activities, frequency shall be a minimum of once per site. |
| Abrasive blast profile measurements | NACE SP0287, section 2.6.19 | Sections 2.10.1, 2.10.2 and Table 2-4 |
| Monitor steel pre-heat (if required) | As required by Manufacturer datasheets | Every item to be coated |
| ASTM D4752 MEK test | Section 2.7.10 | Every item coated with inorganic zinc primer |
| DFT | SSPC-PA 2, sections 2.7.12 and 2.7.14 | Section 2.7.13 |
| Visual inspection of application | Section 2.7.16 | Every item coated |
| Holiday detection | NACE SP0188, section 2.11.1 | Painted items under thermal or acoustical insulation (section 2.11.1) |

2.9.5 Additional sampling shall be performed where a test fails to conform to the specified requirements to ascertain the extent of the non-conforming paint. At the Company's discretion, all affected paint determined to have failed the testing may be rejected. Rejected items shall be stripped and repainted at the expense of the Applicator.

## 2.10 Inspection and Testing—Anchor Profile Measurement Frequency

2.10.1 Surface profile measurements shall be conducted in accordance with Table 2-4. The minimum number of readings listed within the table shall be conducted.

2.10.2 If a trailer load or large shipment of piping, fittings, valves, pipe supports or multiple pre-fabricated assemblies are to be abrasively cleaned for painting, the frequency of profile measurements listed may be changed to four (4) measurements per hour of abrasive blasting at the discretion of the Company Coating Inspector. Blast profile reading measurements shall be taken at different locations on the items abrasively cleaned. If this process occurs, it shall be documented on the Company approved QC form.

**Table 2-4: Profile Measurement Recordings**

| Object | Size | Minimum Number of Spot Readings |
|---|---|---|
| Pipe | Every 20 linear meters (65 ft.) | 4 randomly spaced along and around the pipe |
| Fittings | Each, less than 20 linear meters (65 ft.) | 4 randomly spaced along and around the fitting |
| Pipe sections | Each, less than 20 linear meters (65 ft.) | 4 randomly spaced along and around the pipe section |
| Girth welds and tie-in welds | 1 set of 3 readings per 25 joints | 3 per joint in different quadrants of the girth weld or tie-in weld |
| Valves | Each | 3 along and around the valve for ≥ 406 mm (16 in.)<br>2 along and around the valve for < 406 mm (16 in.) |
| Pre-fabricated valve assemblies (all sizes) | Each assembly | 6 randomly spaced along and around the assembly for ≥ 406 mm (16 in.)<br>4 randomly spaced along and around the assembly for < 406 mm (16 in.) |
| Large repair areas | Surfaces of repair areas exceeding 25 $cm^2$ (4 $in.^2$) | 1 reading every 2nd repair area |
| Other items not listed | N/A | 4 readings per hour of blasting |

## 2.11 Inspection and Testing—Holiday Detection

2.11.1 Paint systems intended for service under thermal or acoustical insulation, inside or outside a building, shall be confirmed to be free of holidays by inspection with a low-voltage wet sponge holiday tester in accordance with NACE SP0188 *Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates*.

## 2.12 Handling and Storage

2.12.1 Painted items shall be handled, transported and stored in a manner that avoids damage to the paint system or items. Any damage to the items or the paint shall be repaired in accordance with the applicable standards and this Specification.

# 3 VARIANCES

Any deviation shall follow the Company Management of Change (MOC) Variance Procedure (EDMS No. 7728702). External vendors shall contact the Company Responsible Engineer or another authorized Company representative for variance approval.

# 4 ROLES AND RESPONSIBILITIES

Table 4-1 lists the roles and responsibilities required for the use of this Specification.

**Table 4-1: Roles and Responsibilities**

| Role | Responsibilities |
|---|---|
| Applicator | The Applicator is responsible for ensuring that the proper method is used to apply the appropriate paint materials to the appropriate surface area. |
| Company Coating Inspector | The Company Coating Inspector is responsible for ensuring that the Applicator uses the proper method to apply the paint materials to the appropriate surface area, and that the results meet the standards set forth by the Company in this Specification. |
| Responsible Engineer | The Responsible Engineer is accountable for ensuring that the plan set forth by the Applicator meets the standards set forth by the Company, and that resolution to any questions that arise from the use of this Specification meet the standards set forth by the Company. |
| Manufacturer | The Manufacturer is responsible for ensuring that the product produced for application is produced in accordance with the documentation that it provides to the Applicator. |

# 5 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are listed in Table 5-1, Table 5-2 and Table 5-3. Use the latest document revision, unless otherwise approved by TransCanada.

**Table 5-1: Regulatory References**

| Organization/Document No. | Title |
|---|---|
| For this Specification, there are no specific regulatory references. | |

**Table 5-2: External Industry References**

| Organization/Document No. | Title |
|---|---|
| American Society for Testing and Materials (ASTM) | ASTM D4285 Standard Test Method for Indicating Oil or Water in Compressed Air |
| | ASTM D4752 Standard Practice for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub |
| International Organization for Standardization (ISO) | ISO 9001 Quality Management Systems – Requirements |
| | ISO 12944 Paints and varnishes – Corrosion protection of steel structures by protective paint systems |
| National Association of Corrosion | NACE SP0188 Discontinuity (Holiday) Testing of New Protective Coatings |

| Organization/Document No. | Title |
|---|---|
| Engineers (NACE) International | on Conductive Substrates |
| | NACE SP0287 Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape |
| The Society for Protective Coatings (SSPC) | SSPC-PA 2 Procedure for Determining Conformance to Dry Coatings Thickness |
| | SSPC-SP 1 Solvent Cleaning |
| | SSPC-SP 2 Hand Tool Cleaning |
| | SSPC-SP 6/NACE No. 3 Commercial Blast Cleaning |
| | SSPC-SP 10/NACE No. 2 Near-White Blast Cleaning |
| | SSPC-SP 15 Commercial Grade Power Tool Cleaning |
| | SSPC Technology Guide 15 Field Methods for Extraction and Analysis of Soluble Salts on Steel and Other Nonporous Substrates |
| | SSPC-VIS 1 Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning, 2002 Revision |

**Table 5-3: Internal References**

| Document No. | Title |
|---|---|
| EDMS No. 5880500 | *TEF-CO-PAINT-GL Coating Inspection Form for: Above Ground Painting (CAN-US-MEX)* |
| EDMS No. 3671710 | *TES-CO-EPU-GL Field-Applied External Liquid Coating Systems for Steel Pipes Specification (CAN-US-MEX)* |

## 6 DOCUMENTATION AND RECORDKEEPING

All Project documentation is held in the Project file and stored in accordance with the Company's guidelines.

All technical document submittal requirements are provided in the Vendor Technical Document Requirements List (VDRL) included with the proposal request or purchase order.

## 7 DOCUMENT HISTORY

| **Rev.** | | |
|---|---|---|
| **10** | **Description** | **Effective Date** |
| | This document is the new version of TES-COAT-PAINT-GL, updated in accordance with the CPG Integration. | 2017-Aug-01 |
| | **Rationale Statement** | **Responsible Engineer** |
| | This document was developed / revised in order to address the following requirements:<br>• CPG Integration | Aissa Van Der Veen, P. Eng. |
| | **Impact Assessment Summary** | **Document Owner** |
| | This Specification was revised to integrate the TransCanada and CPG documents. | Aissa Van Der Veen, P. Eng. |
| **Rev.** | | |
| **09** | **Description** | **Effective Date** |
| | This document is the new version of TES-COAT-PAINT-GL, updated in accordance with the documentation Streamlining initiative. | 2016-Nov-01 |
| | **Rationale Statement** | **Responsible Engineer** |
| | This document was developed / revised in order to address the following requirements:<br>• Streamlining of content to reflect the updated document collection of the coatings group | Aissa Van Der Veen, P. Eng. |
| | **Impact Assessment Summary** | **Document Owner** |
| | This Specification was revised to streamline the documentation required for the Coatings group and to make it more easily accessible to those who use it. | Aissa Van Der Veen, P. Eng. |

## 8 DESCRIPTION OF CHANGE

| **Section** | **Description of Change** |
|---|---|
| **Regulatory** | |
| N/A | N/A |
| **Industry Standards** | |
| N/A | N/A |
| **General** | |
| Update to format and content | As a part of the Streamlining and Simplification process, this document has been reformatted and updated to reflect the TransCanada template. |

## 9 APPROVALS

| APPROVALS | | |
|---|---|---|
| Originator:<br>Aissa Van Der Veen, P. Eng.<br>Welding and Materials Engineering | Signature | Date: July 12, 2017 |
| Reviewer:<br>Niteesha Falcon, P. Eng.<br>Welding and Materials Engineering | Signature: Niteesha Falcon | Date: July 15, 2017 |
| Reviewer:<br>Connor McManus, P. Eng.<br>Gas Projects Engineering | Signature: Jim Lyfield FOR Connor McManus | Date: JULY 14, 2017 |
| Reviewer:<br>Daniel Herpin, Manager<br>Corrosion Services | Signature: D. Herpin | Date: July 13, 2017 |
| Responsible Engineer:<br>Aissa Van Der Veen, P. Eng.<br>Welding and Materials Engineering | Signature<br>Date: July 15, 2017 | PROFESSIONAL ENGINEER ALBERTA AISSA VAN DER VEEN<br>APEGA Permit to Practice P7100 |
| Management Endorsement:<br>James Ferguson, P. Eng., Manager<br>Welding and Materials Engineering | Signature: Jim Ferguson | Date: July 15, 2017 |

## APPENDIX A APPROVED PAINTS FOR ISO 12944 CLASSIFICATION C1, C2 AND C3

This Appendix lists approved paints for ISO 12944 Classification C1 & C2 (heated building/neutral atmosphere, rural areas and low pollution) and C3 (urban and industrial atmospheres, moderate sulphur dioxide levels and production areas with high humidity). This procedure applies to both shop and field work under a full range of operating conditions. These systems are not suitable for coastal environments (ISO 12944 C4).

The following tables list the approved paint Manufacturers and the generic product description. There are nine (9) paint Manufacturers listed, which are displayed in no specific order.

### A-1 PAINT SYSTEMS

The list of paintable items present within the following tables is not exhaustive. If an item that requires painting is not listed in the tables, Projects are requested to review where the item is to be installed (inside or outside) and what items are attached to it (upstream or downstream). If the upstream or downstream items are listed and the item to be painted is in the same atmospheric classification and does not generate or induce heat into the system, the paint system of the listed items may be used. Refer to Appendix Table A-2 and Appendix Table A-3 for primer and topcoat product information.

**Appendix Table A-1: Paint Systems**

| Paint System** | Items to be Painted | Surface Prep | Primer | | Topcoat | | Total DFT target range for these environments | Comments |
|---|---|---|---|---|---|---|---|---|
| | | | Paint Code | Minimum DFT | Paint Code | Minimum DFT | | |
| **Paint Systems for Items Within Buildings (Indoor Atmospheric Service, C1 & C2 Environments)** | | | | | | | | |
| **PS-I-2** | Steel Floor Grating & Plates, Steel Stairs, Ladders & Walkways | SP-6 | P1 | 6 mils | - | - | 6 mils minimum | • Items may be galvanized as per the Industry Standard (2 mils minimum).<br>• Painting is required if specified in the Project description. |

| Paint System** | Items to be Painted | Surface Prep | Primer | | Topcoat | | Total DFT target range for these environments | Comments |
|---|---|---|---|---|---|---|---|---|
| | | | Paint Code | Minimum DFT | Paint Code | Minimum DFT | | |
| **Paint Systems for Items Outside Buildings (Outdoor or Wet Atmospheric Service, C3 Environments)*** | | | | | | | | |
| **PS-O-1** | Pipe and Cable Supports | SP-6 | P8 | 8 mils | - | - | 8 mils minimum | • If piping and cable supports are aluminum or pre-finished, no painting is required.<br>• For small maintenance and touch ups, surface preparation to SP-15 is acceptable in place of SP-6.<br>• This does not include structural steel such as I-beams and above ground piles. These items may be galvanized as per the Industry Standard (2 mils minimum). |
| | | SP-6 | P1 | 6 mils | F2 | 2 mils | | |
| | | SP-6 | P1 | 6 mils | F10 | 2 mils | | |
| **PS-O-2** | Steel Ladders, Stairs and Treads, Grating, Walkways, Handrails, Checker plates | SP-6 | P1 | 6 mils | F2 | 2 mils | 8 mils minimum | • For checker plates located outside of buildings.<br>• Items may be galvanized as per the Industry Standard (2 mils minimum). |
| | | SP-6 | P1 | 6 mils | F10 | 2 mils | | |
| **PS-O-5** | Steel Water Tank Exterior | SP-6 | P1 | 6 mils | F2 | 2 mils | 8 mils minimum | • For small maintenance and touch ups, surface preparation to SP-15 is acceptable in place of SP-6. |
| | | SP-6 | P1 | 6 mils | F10 | 2 mils | | |
| | | SP-10 | P8 | 8 mils | - | - | | |

| Paint System** | Items to be Painted | Surface Prep | Primer | | Topcoat | | Total DFT target range for these environments | Comments |
|---|---|---|---|---|---|---|---|---|
| | | | Paint Code | Minimum DFT | Paint Code | Minimum DFT | | |
| **Paint Systems for Equipment Within Buildings (Dry Indoor Atmospheric Service, C1 & C2 Environments)** | | | | | | | | |
| **PS-I-5** | General Equipment (except compressor), and High Pressure Pipe: Natural Gas, Air, Oil or Water (including composite repair sleeves) | SP-6 | P1 | 6 mils | - | - | 6 mils minimum | |
| **PS-I-7** | High Pressure Pipe in trench (not buried): Natural Gas, Air, Oil or Water (including composite repair sleeves) | SP-10 | P4 | 4 mils | P1 | 4 mils | 6 mils minimum | • Organic Zinc Rich Primer (P7) is allowed as a substitute to P4 if cool dry ambient conditions will retard curing of the inorganic zinc primer. It is also allowed for painting repairs. |
| | | SP-6 | P1 | 4 mils | F10 | 2 mils | | |
| **PS-I-8** | Insulated Pipe (Natural Gas, Air, Oil or Water) (thermal or acoustic insulation) | SP-6 | P6 | 6 mils | - | - | 6 mils minimum | • Topcoat paint shall be confirmed to be free of holidays inside and outside of buildings. |
| **PS-I-9** | Turbine (Exhaust) Expansion Joint (Exhaust) Muffler – Max temp 399°C (750°F) | SP-10 | P4 | 4 mils | F7 (b) | 1.5 mils | 6 mils minimum | |
| **PS-I-10** | Turbine (Exhaust) Expansion Joint (Exhaust) Muffler – Max temp 538°C (1000°F) | SP-10 | P9 | 4 mils | F7 (a) | 1.5 mils | 6 mils minimum | |

| Paint System** | Items to be Painted | Surface Prep | Primer | | Topcoat | | Total DFT target range for these environments | Comments |
|---|---|---|---|---|---|---|---|---|
| | | | Paint Code | Minimum DFT | Paint Code | Minimum DFT | | |
| **Paint Systems for Equipment Outside Buildings (Outdoor or Wet Atmospheric Service, C3 Environments)** | | | | | | | | |
| **PS-O-6** | Air Intake Filter ,Fin/Fan Cooler, Blow off cleaner (Air Unit and Auxiliary Engine), Post (Instrument) Scrubber (Air),Pipe (Air, Water, Oil), Surge Bottle | SP-6 | P8 | 8 mils | - | - | 8 mils minimum | |
| | | SP-6 | P1 | 6 mils | F2 | 2 mils | | |
| | | SP-6 | P1 | 6 mils | F10 | 2 mils | | |
| **PS-O-7** | Turbine (Exhaust) Expansion Joint (Exhaust) Muffler – Max temp 399°C (750°F) | SP-10 | P4 | 6 mils | F7 (b) | 1.5 mils | 8 mils minimum | • Organic Zinc Rich Primer (P7) is allowed as a substitute to P4 if cool dry ambient conditions will retard curing of the inorganic zinc primer. It is also allowed for painting repairs. |
| **PS-O-8** | Turbine (Exhaust) Expansion Joint (Exhaust) Muffler – Max temp 538°C (1000°F) | SP-10 | P9 | 6 mils | F7 (a) | 1.5 mils | 8 mils minimum | |
| **PS-O-9** | Piping system and Separators (Natural Gas and Crude Oil) (Including composite repair sleeves), Heat Exchangers | SP-10 | P4 | 5 mils | F9 | 3 mils | 8 mils minimum | • Organic Zinc Rich Primer (P7) is allowed as a substitute to P4 if cool dry ambient conditions will retard curing of the inorganic zinc primer. It is also allowed for painting repairs. |
| | | SP-6 | P1 | 6 mils | F10 | 2 mils | | |
| **PS-O-10** | Insulated Pipe and other insulated surfaces (thermal or acoustic insulation) | SP-10 | P6 | 5 mils | P6 | 5 mils | 8 mils minimum | • Topcoat paint shall be confirmed to be free of holidays inside and outside of buildings. |

**Notes:**

* Painting is not required on the underside of meter station skids or compressor station skids and other areas of the skid that are not readily visible.

** The “O” in the paint system code refers to items outside a building and the “I” in the paint system code refers to items inside a building.

## A-2 PRIMERS AND TOPCOATS

The entire paint system must be selected from a single Manufacturer.

**Appendix Table A-2: Primer Product Name by Manufacturer**

| Paint Code | Paint Type | Manufacturer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Amercoat/PPG | Carboline | Cloverdale | Devoe | Hempel | Highland International | International | Sherwin Williams | Tnemec |
| P1 | Surface Tolerant Epoxy | Amercoat 370 | Carboguard 890[1] or Carbomastic 615 HS | ClovaMastic HB Low Temp Cure Epoxy 83110 Series | Bar Rust 236 | Hempadur Fast Dry 17410 | - | Interseal 670HS[2] | Macropoxy 646[3] | Epoxoline Series 141 |
| P2 | Universal Primer | PPG Multi-prime 4360 | Carbocoat 150UP | Rustex low VOC primer 71044 | Devprime 1407 | Uni-Primer 13140 | - | Interprime 198/298 shop/field[4] | Kem Bond HS | ChemPrime H.S. Series 37H |
| P4 | Inorganic Zinc Rich Primer | Dimetcote 9 | Carbozinc 11 | ClovaZinc 2 | Cathacoat 304L | Galvosil 15680 | - | Interzinc 22 | Zinc Clad II Plus | Tneme-Zinc Series 90-E92 |
| P6 | Phenolic / Novalac Epoxy | Hi-Temp 900[5] | Thermaline 450/ 450EP | ClovaLine 83375 | - | Hempadur 85671 | 47 Series Chem-Temp Epoxy | Intertherm 228HS or Interbond 2340 UPC[5] | Cor-Cote HT | Novocoat SC 2200[5] |
| P7 | Organic Zinc Rich Primer | Amercoat 68 HS | Carbozinc 859 | ClovaZinc 3 | Cathacoat 313 | Hempadur Avantguard 750 | - | Interzinc 52 | Zinc Clad III HS | Tneme-Zinc Series 90-97 |
| P8 | Epoxy Polysiloxane | PSX 700[6] | - | - | - | Hempaxane Classic 55000 | - | - | Sherloxane 800 | - |
| P9 | Zinc Primer (for Silicone Topcoat) | Dimetcote 9 Series | Carbozinc 11 | ClovaTherm 83220 | Cathacoat 304L | Galvosil 156801 | 335 Series | Interzinc 22 | Zinc Clad II Plus[7] | Tneme-Zinc Series 90-E92 |

| Paint Code | Paint Type | Manufacturer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Amercoat/PPG | Carboline | Cloverdale | Devoe | Hempel | Highland International | International | Sherwin Williams | Tnemec |

**Notes:**

(1): For applications above 10°C (50°F) use Carboguard 890, for applications down to 2°C (35°F) use Carboguard 890LT and for applications down to -7°C (20°F) use Carbomastic 615HS (tan only). It is acceptable for CPG facilities to substitute Rustbond Polymeric Amine epoxy primer for repairs only.

(2): Use Intergard 345 for shop work.

(3): Use Macropoxy 846 for cold weather application

(4): The 198 is shop applied. The 298 is VOC compliant field applied.

(5): These paint products can be used as a standalone paint system for uninsulated pipe. Follow the Manufacturer's recommendations for thickness requirements and surface preparation. Ensure desired project colour can be obtained from the Manufacturer. A topcoat may be applied to achieve the desired colour.

(6): Use PSX 700FD in Canada or if fast dry is required.

(7): Use Heat Flex Hi Temp 1200 for low humidity environments.

### Appendix Table A-3: Topcoat Product Name by Manufacturer

| Paint Code | Paint Type | Manufacturer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Amercoat/PPG | Carboline | Cloverdale | Devoe | Hempel | Highland International | International | Sherwin Williams | Tnemec |
| F1 | Alkyd Enamel | HPC Industrial Alkyd 4308 H Series | Carbocoat 8215 | Industrial Enamel | Devlac 1431, Devlac 1433 | Hempalin Enamel 52140 | - | Interlac 665/ 665FD | Industrial Enamel HS | Tneme-Gloss Series 2H |
| F2 | Polysiloxane Topcoat | PSX One | Carboxane 2000 | Polysiloxane HP | - | Hempaxane Light 55030 | - | Interfine 878 | Polysiloxane 1k | UVX Series 740 |
| F3 | Water Borne Epoxy or Epoxy Acrylic | Aquapon WB 98-1 Series | Sanitile 255 or 555 | ClovaShield | Truglaze 4420 | Hempadur Mastic 45880 | - | - | Pro-Industrial WB Catalyzed Epoxy | HB Tneme-Tufcoat Series 113/114 |

| Paint | Paint Type | Manufacturer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| F5 | Water Borne Acrylic | Pitt-Tech Plus 90-1310 | Carbocrylic 3359 | Ecologic WB Speed Enamel | Devcryl 1449 | - | - | - | DTM Acrylic | Enduratone Series 1029 |
| F7 (a) | Silicone Aluminum | Hi Temp 1000(1) or Dimetcote 9 | Thermaline 4700 | ClovaTherm 83225 | - | Silicone Aluminum 56913 | 815 Series | Intertherm 50 | Heat Flex Hi-Temp 1000 | - |
| F7 (b) | High Temp Inorganic | Hi Temp 1027 | Thermaline 4000 | HH Aluminum 83203 | - | Versiline 56990 | - | Interbond 1202UPC | Heat Flex Hi Temp 1200 | - |
| F8 | Abrasion Resistant Epoxy | MegaSeal HSPC/PPG MegaSeal SL | Sanitile 945SL | NSP 100/200 | Devgrip 238 | Hempadur Multi-Strength 35530 | - | Interzone 954 | Armorseal 650 SL/RC | Epoxoline Series 142 |
| F9 | Modified Polysiloxane | PSX 700(2) | Carboxane 2000 | Polysiloxane HP | - | Hempaxane Light 55030 | - | Interfine 979 | Sheloxane 800 | UVX Series 740 |
| F10 | Polyurethanes | Amercoat 450HS | Carbothane 134HG or HB, Carbothane 133HG or HB(3) | AmourShield | Devthane 389H or Devthane 379(4) | Hempathane HS 55610 | - | Interthane 990V | Acrolon 218HS or Envirolastic 940PA | Endura-Shield Series 1095 |

**Notes:**

(1): Cure for 2 hrs at 149°C (300°F) before service, for other colors use Amercoat 873, no heat cure is required.

(2): Use PSX 700FD in Canada or if fast dry is required.

(3): For a satin gloss finish to aid in hiding weld seams and other types of defects, use Carbothane 133HB.

(4): Devthane 379 is for use in Canada and Devthane 379H is for use in the U.S.

# APPENDIX B PAINT SYSTEMS FOR ISO 12944 CLASSIFICATION C4 (INDUSTRIAL AND COASTAL AREAS, CHEMICAL PROCESSING PLANTS)

## B-1 PAINT SYSTEMS

This Appendix lists the approved paints for ISO 12944 Classification C4 (industrial and coastal areas with moderate salinity and chemical processing plants). Coastal environments include systems within 5 km (3 mi.) of salt or brackish water and areas exposed to brine or salt. Coating materials shall be selected and applied as systems in accordance with the intended service as required by Appendix Table B-1.

This Procedure applies to both shop and field work under a full range of operating conditions. The following tables list the approved paint Manufacturers and the generic product description.

Refer to Appendix Table B-2, Appendix Table B-3, Appendix Table B-4 and Appendix Table B-5 for primer, intermediate coat and topcoat information.

### Appendix Table B-1: Paint Systems

| Paint System | Items to be Painted | Maximum Service Temperature | Surface Prep | Primer(1) | | Intermediate Coat | | Topcoat | | Total DFT target range for these environments | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Paint Code | Minimum DFT | Paint Code | Minimum DFT | Paint Code | Minimum DFT | | |
| **PS-C-1** | Piping and structural steel | 120ºC (248ºF) | | PC1 | 3 mils | IC1 | 7 mils | FC1 | 3 mils | 13 mils | |
| **PS-C-2** | Pipe and cable supports | 120ºC (248ºF) | | PC2 | 4 mils | - | - | FC2 | 7 mils | 11 mils | |
| **PS-C-4** | Steel under insulation (thermal or acoustic) | 260ºC (450ºF) | | PC3 | 6 mils | - | - | FC3 | 7 mils | 13 mils | • Coating shall be confirmed to be free of holidays with a wet sponge holiday tester. Phenolic/Novalac Epoxies typically are suitable for service temperatures up to 200°C to 260ºC (400°F to450ºF); refer to the Manufacturer's product datasheet for maximum service temperatures. |

**Notes:**

(1): For maintenance situations, when the method of surface preparation is not abrasive blast cleaning (e.g., water blasting or power tool cleaning) the Surface Tolerant Primer should be used. Refer to Appendix Table B-3.

## B-2 PRIMERS AND TOPCOATS

The entire paint system must be selected from a single Manufacturer.

**Appendix Table B-2: Primer Product Names by Manufacturer**

| Paint Code | Paint Type | Manufacturer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Amercoat / PPG | Carboline | Cloverdale | Devoe | Hempel | Highland International | International | Sherwin Williams | Tnemec |
| PC1 | Zinc | Amercoat 68HS | Carbozinc 859 | ClovaZinc 3 | Cathcoat 313 | Hempadur Avantguard 750 | - | Interzinc 52 | ZincClad III HS | Tneme-zinc Series 90-97 |
| PC2 | Zinc | Amercoat 68HS | Carbozinc 859 | ClovaZinc 3 | - | Hempadur Avantguard 750 | - | Interzinc 52 | ZincClad III HS | Tneme-zinc series 90-97 |
| PC3 | - | Amercoat 90HS | Thermaline 450EP | ClovaMastic Micaceous HR Mastic | - | Hempadur 85671 | 47 Series Chem-Temp Epoxy | Intertherm 228HS or Interbond 2340 UPC | Cor-Cote HT | Epoxoline WB Series 1224 |

**Appendix Table B-3: Alternative Primer**

| Paint Type | Manufacturer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Amercoat / PPG | Carboline | Cloverdale | Devoe | Hempel | Highland International | International | Sherwin Williams | Tnemec |
| Surface Tolerant Primer | Amercoat 370 | Carbomastic 15(1) | ClovaMastic 83110 Series | - | Hempadur Mastic 45880 | - | Interseal 670HS | Sea-Guard 6100 | Epoxoline Series 141 |

**Notes:**

(1): For maintenance painting Carbomastic 615 may be used instead of Carbomastic 15 for cold or slightly damp surfaces.

### Appendix Table B-4: Intermediate Coat Product Names by Manufacturer

| Paint Code | Paint Type | Manufacturer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Amercoat / PPG | Carboline | Cloverdale | Devoe | Hempel | Highland International | International | Sherwin Williams | Tnemec |
| IC1 | Epoxy | Amercoat 385 | Carboguard 893 | ClovaGuard | Bar Rust 236 | Hempadur Fast Dry 17410 | - | Interseal 670HS or Intergard 475HS | Macropoxy 646(1) | Hi-Build Epoxoline Series 66 HS(2) |

**Notes:**

(1): For cold weather application use Macropoxy 846.

(2): For cold weather application use Hi-Build Epoxoline Series 161 HS Low Temperature

### Appendix Table B-5: Topcoat Product Names by Manufacturer

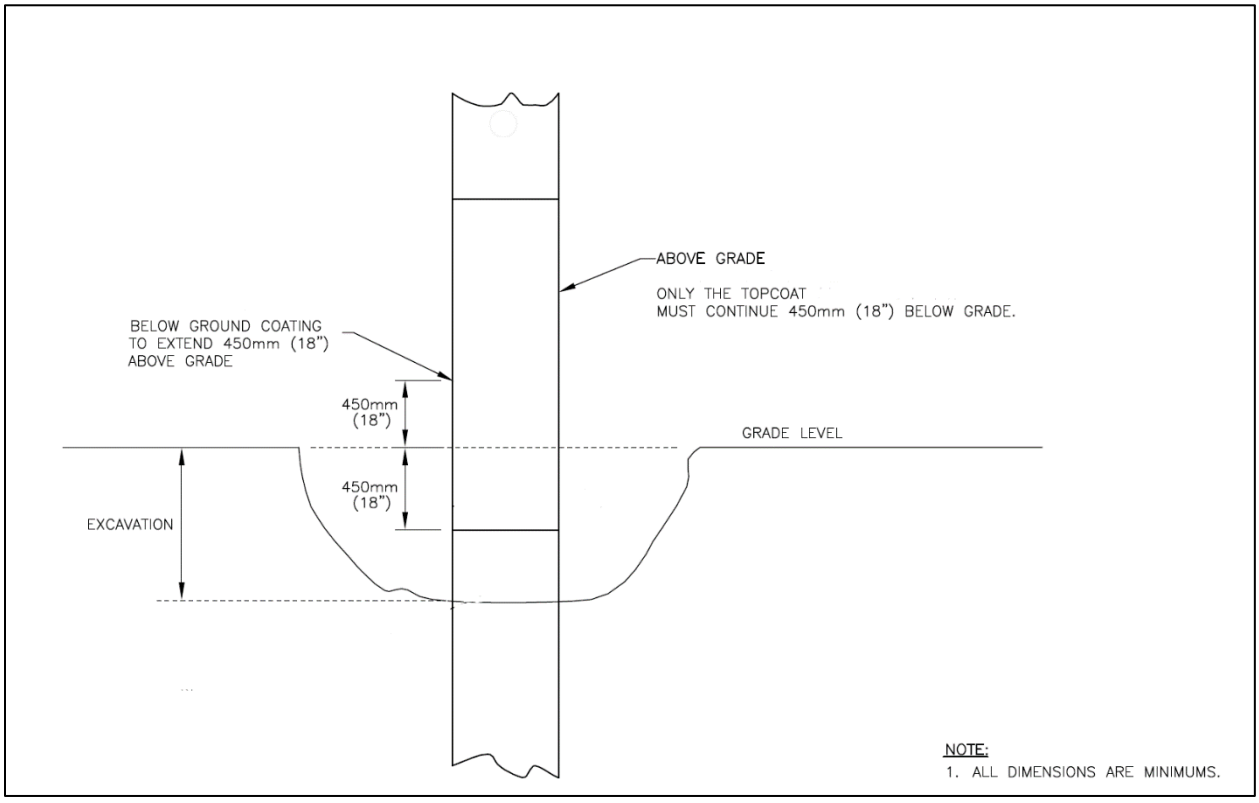
| Paint Code | Paint Type | Manufacturer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Amercoat / PPG | Carboline | Cloverdale | Devoe | Hempel | Highland International | International | Sherwin Williams | Tnemec |
| FC1 | Urethane | Amercoat 450HS | Carbothane 134HG | AmourShield | Devthane 379V | Hempathane HS 55610 | - | Interthane 990 V | Acrolon 218 HS | Endura Shield II Series 1074 |
| FC2 | Polysiloxane | PSX 700 | Carboxane 2000 | Polysiloxane HP | - | Hempaxane Light 55030 | - | Interfine 979 HS | Sherloxane 800 | UVX Series 740 |
| FC3 | - | Amercoat 90HS | Thermaline 450EP | ClovaMastic Micaceous HR Mastic | - | Hempadur 85671 | 47 Series Chem-Temp Epoxy | Intertherm 228HS or Interbond 2340 UPC | Cor-Cote HT | Epoxoline WB Series 1224 |

## APPENDIX C RISERS AND ABOVE GRADE TRANSITION AREAS

Risers and transition areas shall be coated with spray or brush grade liquid coating and shall be applied in accordance with *TES-CO-EPU-GL Field-Applied External Liquid Coating Systems for Steel Pipes Specification (CAN-US-MEX)* (EDMS No. 3671710). The below grade liquid coating shall continue above ground for a minimum of 45 cm (18 in.).

For areas with stable soils, the above ground topcoat paint must continue approximately 45 cm (18 in.) below ground. For areas with unstable soils, the above ground topcoat paint must continue for approximately one (1) meter (3 ft.) underground. The paint topcoat shall be applied in accordance with this Specification.

For existing FBE or liquid coating systems, only the topcoat of the above ground paint system must continue, approximately 45 cm (18 in.) below grade, and be applied in accordance with this Specification. For more details, refer to Appendix Figure C-1.




**Appendix Figure C-1: Riser Coating Detail with Transition to FBE or Liquid Coating Systems**

# APPENDIX D ABOVE GROUND FILLING AND OVER WRAPPING FLANGES PROCEDURE (CPG ONLY)

## D-1 SCOPE

This Procedure provides guidance for the application of filling and over-wrapping flange assemblies for above ground applications.

## D-2 APPROVED MATERIALS

Trenton #2 Wax Tape above ground (maximum temperature 60°C (140° F)).

## D-3 PREREQUISITES

The following items *must* be completed or reviewed before beginning this Procedure.

- Consideration needs to be given for the operating temperature of the flange assembly.

## D-4 PROCEDURE

Filling Procedure – Above Ground

1. Assess the condition of the entire flange assembly (i.e., bolts, nuts, gaskets and pipe) for corrosion on existing facilities.
2. Prior to filling, the flange should be cleaned, at a minimum, per SSPC-SP 1 *Solvent Cleaning* to remove any grease, oil, chemical contaminant, etc. If necessary, utilize SSPC-SP 2 *Hand Tool Cleaning* to remove any loose debris, rust, flaking paint, etc. The area between the flanges can be blown out with compressed air to remove any loose deposits.
3. Lightly coat the gasket/flange area with wax tape primer. Insert the profiling mastic into the flange, working the product around the flange bolts and into the flange crevice. Remove the excess profiling mastic from the flange circumference. Install Trenton #2 Wax Tape around the flange. A fiberglass outer wrap and/or paint can also be applied where needed.

## PURPOSE

This Specification outlines the requirements for the qualification, application, inspection, repair and testing of plant-applied fusion bond epoxy (FBE) coatings intended for gas and liquid pipeline systems.

## SCOPE/APPLICABILITY

This Specification shall comply with the requirements of the latest edition of Canadian Standards Association (CSA) Z662 *Oil and Gas Pipeline Systems* and CSA Z245.20-14 *Plant-applied external fusion bond epoxy coating for steel pipe* and any amendment, supplement or errata issued by CSA.

This Specification shall be used in conjunction with CSA Z245.20-14 and covers the requirements that are in addition to the CSA Z245.20-14 requirements.

The numbering of clauses in this Specification corresponds to the numbering of clauses in CSA Z245.20-14 where the subject is covered, with any additional clauses numbered sequentially.

A pre-qualification of each application facility is required prior to the application of any approved FBE powders. The pre-qualification tests to be undertaken are provided in Table 12-1 (System 1A) and Table 12-2 (System 2B and 2C) of this Specification.

The coating Applicator facilities shall be Company approved Applicators.

This Specification applies to all divisions of the Company and its wholly-owned subsidiaries, and all operated entities/facilities in Canada, the United States (U.S.) and Mexico.

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

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

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# 1 SCOPE

This Specification outlines the technical requirements for the qualification, application, inspection, testing, handling and storage of materials required for plant-applied fusion bond epoxy (FBE) corrosion coating and abrasion resistant FBE coating applied externally to bare steel pipe for gas and liquid pipeline systems. FBE is suitable for piping sizes NPS 4 and larger. Depending on the application facility, there may be some wall thickness, length and weight restrictions. Due to heating requirements, this Specification (as written) may not be suitable for a strain based pipe design.

This Specification applies to the Company and to all coating Applicators of FBE coating and abrasion resistant FBE coating for newly constructed gas and liquid pipeline systems and pipe replacement programs.

The coating Applicator shall be referred to as the Contractor and the Company's authorized representatives shall be referred to as the Inspectors.

If the Contractor is familiar with the work to be performed pursuant to this Specification, the Contractor shall represent, and has the responsibility of compliance with, all of the applicable regulations, codes, standards and specifications (including those related to occupational safety and environmental protection).

The FBE coating in this Specification is suitable for operating temperatures up to 65°C (150°F) and ambient installation temperatures of -30°C (-20°F) and higher.

The conversion of units from metric to imperial and vice versa shall be to the nearest approximate values of zero or five.

The FBE powders, application process and coating system shall meet the requirements of CSA Z245.20-14 and this Specification.

1.2 This Specification covers the following coating systems:

- System 1A (FBE corrosion coating or single layer)
- System 2B (FBE corrosion coating and FBE resistant overlay or ARO or dual layer)
- System 2C (FBE corrosion coating and an anti-slip overcoat)

# 2 REFERENCE PUBLICATIONS

All documentation required by CSA Z245.20-14 and this Specification shall be available at the coating Applicator's facilities.

In addition, the latest versions of the following should be available and complied with:

- DOT 49 CFR 192 *Transportation of Natural and Other Gas by Pipeline*
- DOT 49 CFR 195 *Transportation of Hazardous Liquids by Pipeline*
- NACE SP 0394 *Application, Performance, and Quality Control of Plant-Applied Single Layer Fusion-Bonded Epoxy External Pipe Coating*

## 3 DEFINITIONS

The following definitions shall be added to those referenced by CSA Z245.20-14:

**Crack**

A visually determined tear in the coating that extends through to the pipe surface.

**Pimple**

Gas pockets within the coating that are open to the pipe surface but may not be open to the atmosphere. Pimples appear as small protrusions on the coating surface.

**Purchase order**

The purchasing document used to purchase coated pipe.

**Stress or stretch marks**

A tear in the coating that results from flexibility testing that does not extend through to the steel surface. These marks are detected by unaided visual examination but may be verified with the use of up to 40 times magnification. Stress or stretch marks are not to be confused with white marks (which are not open to the atmosphere or steel surface).

**Weld gassing**

Numerous defects in the coating that are predominately located on submerged-arc welds due to the escape of trapped gasses. Such defects are usually detected with electrical inspection in the coating application plant.

## 4 GENERAL REQUIREMENTS

### 4.1.1 Standard Requirements

The following clauses are in the Company purchase order:

(b) pipe quantity, outside diameter, wall thickness, and nominal length;

(c) coating system (1A, 1B, 2A, 2B, 2C, or 3);

(d) bare pipe standard or specification designation; and

(f) cutback length and tolerance for both ends of pipe.

The following clauses are in the appropriate clause of this Specification:

(a) CSA Standard designation and year of publication (Z245.20-14);

(e) nominal thickness and maximum permissible thickness of the coating system, and individual layers if applicable; and

(g) test temperature for the flexibility test (-30, -18, or 0°C).

### 4.1.2 Optional Requirements

The following clauses are in the appropriate clause of this Specification:

(a) additional surface treatments;

(b) plant inspection by the purchaser;

(c) location of laboratory testing;

(d) increased test ring length;

(e) test ring location;

(f) test frequency and retest procedures;

(g) test frequency for additional test rings;

(h) additional markings;

(i) handling procedures;

(j) storage procedures;

(k) waiver of test reports;

(l) gouge test; and

(m) other special requirements.

### 4.3 Requirements for Quality

The Applicator shall have developed and implemented the use of a quality control program that meets the CSA Z245.20-14 requirements. The Applicator shall develop and use an Inspection and Test Plan (ITP) that covers all the requirements of CSA Z245.20-14 and this Specification. The ITP shall list each item to be inspected, the frequency of inspection, the inspection or test procedure, the acceptance criteria and any other details required by the Applicator. The ITP shall also include:

- test incoming fresh and unused (virgin) abrasives for contamination
- fresh or unused acid content
- test bare pipe surface for contamination such as salt
- test recycled and fresh abrasive mixtures for contamination and percent fines
- test abrasive blast cleaned pipe surface for particulate contamination (be specific about particulate contamination)
- type, dimensions and location of separators on pipe (see Clause 10.1.4 in this Specification)
- See Clause 6.2.2.6 in this Specification

For every order, the finalized ITP for each powder to be applied shall be submitted to the Responsible Engineer for review and written acceptance prior to coating commencing. The quality program, the ITP and the Applicator's inspection and/or test

procedures referenced in the ITP shall be available at the coating Applicator's facilities and shall be available for review by the Company.

## 5 MATERIALS

5.1.2 Bare pipe surfaces shall be tested for salt or chloride contamination. Pre-conditioning of the bare pipe shall be applied when directed by the Company.

### 5.2.1 General

(b) (viii) The qualified minimum flexibility test temperature shall be -30°C (-20°F).

### 5.2.2 Properties

(a) System 2B and System 2C

The corrosion coating powder shall meet the requirements of CSA Z245.20-14 Table 1.

### 5.3 Company Approved FBE Powders

Only System 1A and System 2B FBE powders that have been approved and tested in accordance with this Specification and have been applied by an approved Applicator and application facility shall be used. The System 1A tests must pass before the System 2B results will be accepted. For System 2C, once the System 1A tests pass, the Applicator can apply System 2C FBE.

## 6 COATING APPLICATION

6.1.2.2 The surface profile depth, measured from peak to trough, shall be a minimum of 50 µm (2 mils) and shall not exceed 110 µm (4.5 mils).

### 6.1.3 Coating Qualification Test Requirements

The powder manufacturer certifications for CSA Z245.20-14 Table 2 and Table 6 shall include a statement that surface pre-treatments were not performed on any test specimens after grit blasting and before coating.

(a) System 1A

CSA Z245.20-14 Table 2, the flexibility test temperature shall be -30°C (-20°F).

(b) System 2B and System 2C

CSA Z245.20-14 Table 6, the flexibility test temperature shall be -30°C (-20°F), the impact resistance shall be 3.0 J, and the holiday detection voltage shall be at least 5 volts per µm (125 V/mil) of the test specimen coating thickness to a maximum of 5000V.

6.2.2.3 The surface profile depth, measured from peak to trough, shall be a minimum of 50 µm (2 mils) and shall not exceed 110 µm (4.5 mils). If these values fall outside the powder manufacturer's suggested range, the Applicator shall notify the Company

before coating commences so an acceptable minimum, nominal and maximum surface profile depth can be specified.

6.2.2.6 A phosphoric acid surface treatment shall be applied to the external surfaces of each abrasive blast cleaned pipe in accordance with the acid wash manufacturer's recommended procedure. The acid solution shall be applied evenly and, after sufficient reaction time, rinse water shall be used to remove the acid solution and by-products.

The Applicator's ITP shall include, but shall not be limited to:

- acid manufacturer's name and product code
- acid manufacturer's recommended procedure
- residual magnetism of pipe
- conductivity of mix water, solution concentration range to be applied and determining mix concentration
- pipe surface temperature range at time of acid application and minimum acid contact times before rinsing
- conductivity of the rinse water (maximum 35 µS)
- total dissolved solids of the rinse water (maximum 20 ppm)
- rinse water pressure (minimum 1,500 psi)
- pipe pH after rinsing (6 to 7.5)

6.2.3 Application and curing temperatures shall be in accordance with the powder manufacturer's recommendations.

6.2.3.1 Virgin powder

(a) System 1A

At least 150 µm (6 mils) of coating thickness shall be virgin FBE powder as measured from the pipe surface. Thereafter, recycled and virgin mixed FBE powder may be applied within the powder manufacturer's recommended levels.

(b) System 2B

- Corrosion coating layer: At least 150 µm (6 mils) of coating thickness shall be virgin FBE powder as measured from the pipe surface. Thereafter, recycled and virgin mixed FBE powder may be applied within the powder manufacturer's recommended levels.
- ARO: The first layer of abrasion coating may contain recycled abrasion powder within the powder manufacturer's recommended levels. Virgin abrasion powder shall be used for at least the final 150 µm (6 mils) of the abrasion coating thickness.

(c) System 2C

Corrosion coating layer: At least 150 µm (6 mils) of coating thickness shall be virgin FBE powder as measured from the pipe surface. Thereafter, recycled and virgin mixed FBE powder may be applied within the powder manufacturer's recommended levels.

### 6.2.4 Coating Thickness

6.2.4.1 Thickness requirements

(a) System 1A

The coating thickness shall be 355 µm (14 mils) minimum, 405 µm (16 mils) nominal, and 510 µm (20 mils) maximum.

(b) System 2B

The minimum corrosion coating thickness shall be 355 µm (14 mils) and the minimum abrasion coating thickness shall be 405 µm (16 mils). The total coating thickness shall not exceed 1015 µm (40 mils). The nominal corrosion and abrasion coating thickness shall be 865 µm (34 mils). For rocky or aggressive soil conditions, a thicker ARO coating or the application of external liquid coating systems shall be considered. Consult the Responsible Engineer for any coating thickness issues.

(c) System 2C

The corrosion coating thickness shall be 460 µm (18 mils) minimum and 535 µm (22 mils) maximum. The anti-slip overcoat thickness shall be 50 µm (2 mils) minimum and 100 µm (4 mils) maximum.

## 7 INSPECTION AND TESTING

### 7.1 Inspection Notice

The Company, with or without providing the Applicator advanced notice, may inspect the handling, coating process, storage, shipping, and/or witness testing provided all applicable Company and Applicator Health, Safety and Environment (HSE) procedures are followed. The Inspectors shall have access at all times to all work related to the coating application process, with the right to inspect work and material furnished by the Contractor. All such work shall be subject to the approval of the Inspectors. Failure of the Inspectors to identify or reject defective work or materials shall not be construed as acceptance of such work or materials.

7.3.1.1 Preparation, testing and evaluation shall be at the location of coating application.

7.3.1.4

(a) System 1A

CSA Z245.20-14 Table 3, the following additional test shall be conducted: 1.5° flexibility test, CSA Z245.20-14 Clause 12.11, -30°C (-20°F) test temperature, three (3) test specimens, with no cracking and/or no stretch or stress marks.

(b) System 2B and 2C

Tested per CSA Z245.20-14 Table 7, 3.0 J impact test, holiday detection voltage of at least 5 volts per µm of the minimum total coating thickness specified, to a maximum of 5000 V.

7.3.2.1 General

All monitoring, measuring and inspection equipment shall be calibrated and accurate for the range. Heat melt crayons shall not be used for temperature measurements. The inspections and measurements required by CSA Z245.20-14 and Clauses 7.3.2.2 to 7.3.2.14 shall be made by the Applicator.

7.3.2.3 Surface Profile

Replicating film shall not be used on surfaces that are over 65°C (150°F). Where the surface temperature is over 55°C (130°F), the replicating film shall be allowed to air cool for at least two (2) minutes prior to measuring the surface profile. One measurement shall be on the pipe surface and one measurement shall be on a raised weld (where one exists).

7.3.2.7.1.1 Five (5) thickness measurements shall be made on each pipe with a coating thickness gauge for which the calibration has been verified within the last four (4) hours to NIST traceable standards. One of the measurements must be within 1.5 meters of the end of the pipe. The minimum and maximum measured total coating thickness for each pipe must be recorded.

On each pipe, one of the five measurements shall be on a raised weld (where one exists).

7.3.2.7.1.2 The thickness of each individual layer must be recorded at least once every four (4) hours per working shift.

7.3.2.7.2.1 System 1A

Where individual measured thickness values are less than the minimum specified value (Clause 6.2.4.1(a) in this Specification), the coating thickness of the affected pipe shall be measured along the pipe length at intervals not exceeding 1 m.

The average of such measured values for each pipe shall be at least 355 µm (14 mils), and no individual value shall be below 305 µm (12 mils).

Where individual measured thickness values are greater than 510 µm (20 mils), the coating thickness of the affected pipe shall be measured at intervals along the pipe length not exceeding 1 m. The average of such measured values for each pipe shall not exceed 510 µm (20 mils), and no individual value shall exceed 610 µm (24 mils).

7.3.2.7.2.2 System 2B and System 2C

Any individual or total coating thickness below the minimum thickness specified in Clause 6.2.4.1(b) in this Specification is not acceptable. The Company may or may not accept pipe where the maximum total coating thickness is exceeded. Where requested by the Company, for pipe exceeding the total maximum thickness, at the

Applicator's expense (pipe, coating and testing), the Applicator shall perform Company specified coating testing to determine its acceptability.

7.3.2.8.1.1 An additional holiday device shall be used for a second inspection of any raised welds. The Company is not responsible for holidays caused by imperfections, such as steel slivers and weld gassing. The Applicator and pipe manufacturer shall implement procedures to bring the number of repairs in-line with the repair rate typical for pipe without these imperfections.

7.3.2.8.2.2 For pipe with a 355.6 mm OD or larger (≥ 355.6 mm), the acceptance criteria is less than or equal to 0.35 holidays per square metre (≤ 0.35/$m^2$), determined by dividing the total number of holidays by the total outside surface area for the individual pipe tested.

7.3.2.8.2.4 Hand flocking shall not be permitted.

7.3.2.11 The surface temperature and dew point values from CSA Z245.20-14 Clause 6.2.2.2 shall be recorded at least every two (2) hours.

7.3.2.12 The phosphoric acid surface treatment values from Clause 6.2.2.6 in this Specification shall be recorded at least every two (2) hours.

7.3.2.13 The Applicator shall provide records of the powder batch number applied to each pipe or the batch numbers applied to each shift.

7.3.2.14 The cut back shall be monitored and controlled within the limits of CSA Z245.20-14 Clause 6.2.5. These values shall be recorded at least every two (2) hours.

7.3.3.1 Facilities

The Applicator shall perform all Type A and Type B tests at the place of coating application per CSA Z245.20-14 Table 4 and Table 8.

7.3.3.2 Test Rings

Each test ring shall be no more than 500 mm (20 in.) long and located at least 300 mm (12 in.) from a pipe end. On all cut pipe, the pipe shall be bevelled to match the requirements of the applicable pipe standard (see Company purchase order). The cutback area of the test ring may be coated.

7.3.3.3.1

(a) System 1A

The Company may select the pipe for testing.

(b) System 2B and System 2C

A corrosion coating test ring shall also be taken every working shift. See Clause 7.3.3.4.1 and Clause 7.3.3.4.2 in this Specification for the retest procedure for the corrosion coating. The Company may select the pipe for testing.

7.3.3.3.2 One test ring shall be prepared for testing every working shift or every 24 hours.

7.3.3.3.3

(a) System 1A

The coating shall meet the requirements of CSA Z245.20-14 Table 4 and the following:

- 24 hr cathodic disbondment at 65°C (150°F): where the radius of disbondment is in excess of 5.5 mm maximum average radius, the cause shall be investigated by the Applicator and reported to the Company
- 2.5° flexibility test temperature: -30°C (-20°F) with no cracking
- interface contamination: Type A test
- the following additional Type A test shall be conducted: 1.5° flexibility test, CSA Z245.20-14 Clause 12.11, -30°C (-20°F) test temperature, three (3) test specimens, and no cracking and/or no stretch or stress marks

(b) System 2B and System 2C

The corrosion coating test ring shall meet the requirements for System 1A in Clause 7.3.3.3.3(a) of this Specification.

The coating system test ring shall meet the requirements of CSA Z245.20-14 Table 8 and the following:

- 24 hr cathodic disbondment at 65°C (150°F): acceptance criteria is 4.5 mm maximum average radius
- 2.5° flexibility test temperature: -30°C (-20°F) with no disbonding and no cracking and/or no stretch or stress marks
- 24 hr adhesion: rating of 1-3
- 3.0 J impact resistance: holiday tested at 5 volts per µm (125 V/mil) of the test ring coating thickness, to a maximum of 5000V
- the following additional Type A test shall be conducted: 1.5° flexibility test, CSA Z245.20-14 Clause 12.11, -30°C (-20°F) test temperature, three (3) test specimens, no cracking, no stretch or stress marks, no separation of the corrosion coating from the steel or tearing apart of any coating layer (cohesive).

7.3.3.4 Retests

7.3.3.4.1 Adhesion and 24 hour cathodic disbondment retests shall meet the requirements of Clause 7.3.3.3.3(a) or Clause 7.3.3.3.3(b) of this Specification, as appropriate.

7.3.3.4.2 This clause is applicable to coating System 1A, 2B and 2C corrosion coating retests. For an agreed retest frequency, samples of the 2B and 2C corrosion coating may be

obtained by hand filing off the abrasion coating and anti-slip overcoat to expose the corrosion coating, or by an Applicator procedure accepted by the Company.

## 8 REPAIR OF COATED PIPE

### 8.2 Holiday repairs (see Table 9)

(d) Melt sticks are not permitted. All holidays less than or equal to 2 mm maximum diameter or width shall be repaired with two-part epoxy or a Company approved equivalent.

(e) All repairs shall be made with a Company approved cartridge or with a brush grade material with a coating thickness of 510 µm to 890 µm (20 mils to 35 mils) over steel. The approved materials are as follows (listed in alphabetical order):

- Denso North America Inc.: Protal 7200 or 7250
- Specialty Polymer Coatings Inc.: SP-2888 R.G.
- Specialty Polymer Coatings Inc.: SP-3888
- 3M: Scotchkote 327

For all repairs to System 2B, the thickness over steel shall be 890 µm to 1145 µm (35 mils to 60 mils).

For all repairs to System 2C, the thickness over steel shall be 510 µm to 890 µm (20 mils to 35 mils).

(f) Repair materials shall be applied and cured in accordance with the manufacturer's requirements. Cure temperatures shall be continuously above 10ºC until the manufacturer's curing requirements are met. For two-part repairs ≤ 2.0 mm across, the repair materials shall overlap the roughened, cleaned and sound coating by at least 25 mm. For two-part repairs > 2.0 mm and ≤ 160 mm across, the repair material shall overlap the roughened, cleaned and sound coating by at least 50 mm. All roughened coating shall be coated over.

(g) Coating thicknesses shall be per Clause 8.2(e) of this Specification.

(j) Repairs of the cutback section on pipe ends shall be completed with Company approved two-part materials. The repair materials shall be applied and cured in accordance with the manufacturer's requirements. Cure temperatures shall be continuously above 10°C until the manufacturer's curing requirements are met. The area to be repaired shall not exceed 250 $cm^2$.

## 9 MARKINGS

9.2.1

(g) For additional markings, refer to the Company purchase order. A legible and unique pipe identifier shall be paint applied onto the coating on the outside wall at each end of the pipe. Prior to coating application, the Applicator shall submit a marking template/map to the Company for acceptance that includes all the information to be applied onto the coating.

## 10 HANDLING AND STORAGE

The Applicator shall be responsible for any damage occurring to the pipe and/or the coating from unloading to shipping.

10.1.1 The applicable documents shall be at the place of coating application and shall be available to the Company.

10.1.4 Where the separators are affixed to the coated pipe, the affixing material shall minimize the covering of any markings, and the affixing material shall be at least 100 mm (4 in.) from the edge of the coating. The type, dimensions, method of affixing the separators and location of separators on the pipe shall be as per the ITP (see Clause 4.3 in this Specification).

10.2 The Applicator shall submit details of the facilities and the methods to be used for yard storage.

The applicable documents shall be at the place of coating application and shall be available to the Company.

When FBE coated pipe is to be stored for more than twelve (12) months, contact the Responsible Engineer to determine the appropriate coating material to be used to protect the FBE coating from ultraviolet (UV) degradation.

## 11 TEST REPORTS AND CERTIFICATES OF COMPLIANCE

11.1 The Inspection and Test Plan (ITP), the powder manufacturer's certifications and all test reports shall be submitted to the Company. Refer to CSA Z245.20-14 and Clause 4.3 (ITP), Clause 5.2.1, Clause 5.2.2, and Clause 6.1.3 in this Specification.

11.2 Certificates of compliance shall be submitted to the Company.

## 12 TEST PROCEDURES

12.8.3.3 The electrolyte solution shall not be replaced at 7 days, 14 days or 21 days during the 28-day testing period.

### 12.11 Flexibility of the Coating

12.11.3.1 All flexibility tests shall be done at -30°C (-20°F). The bend tester to be used shall hold each flexibility test sample by one end and push it upwards against a cylindrical steel stop. Refer to Appendix A of this specification for photographs of the bend testing equipment to be used.

### 12.12 Impact Resistance of the Coating

12.12.3 Procedure

(f) System 2B and System 2C

The holiday detection voltage shall be 5 V/µm (125 V/mil) of the minimum total coating thickness specified.

### 12.15 Gouge Resistance of the Coating

### 12.15.2 Equipment

The equipment shall consist of the following:

(a) a moveable cart under a fixed point with the following features:

i. an electric motor and a screw drive mechanism to move the cart;

ii. a point that can be loaded with weights to any desired level up to approximately 100 kg;

iii. a replaceable Fullerton R-33 double-cut carbide burr with an angle cone point terminating in a hemispherical tip purchased from Discount Tools (Part Number 48252); and

iv. refer to Appendix B of this Specification for a photograph of the equipment to be used.

### 12.15.3 Test Specimens

Laboratory-coated test specimens will be cut from a coated pipe sample. The circumferential cuts must be perpendicular to the axis. Specimens can measure 25 mm to 155 mm (1 in. to 6 in.) in width and 100 mm to 255 mm (4 in. to 10 in.) in length, with a combined pipe wall and coating thickness of up to 25 mm (1 in.).

### 12.15.4 Procedure

(a) Three (3) test specimens with one (1) gouge test per specimen at test temperatures of -30°C ± 3ºC and 50°C ± 5ºC at a specified load of 30 kg.

(b) Secure the specimen. Use both the weight winch and the arm winch in tandem to adjust the height of the lever arm. The arm will tilt only a few degrees before the counter weights come in contact with the vertical frame members of the pivot rod tower.

(f) Adjust the position of the clamp light to properly light the test specimen area and contact point.

(g) Mark the test specimen with a series of dots at least 0.5 in. apart at the right edge of the selected test area. Place the specimen so that it contacts the backing block. Stack support plates or bars under the specimen until the coating surface of the test specimen is near the level of the top of the backing block. Adjust the position of the cart until the contact point is located over the

right end of the specimen in the selected test area and is aligned with one of the marks.

(h) Perform the following steps:

ii. Perform the test by pushing the directional control switch in the forward test direction (right). Hold the switch until the cart traverses the desired distance, then release the switch. The switch will spring back to its normal “off” position and the motor will stop. Confirm that the contact point remains within the coated area of the test specimen and at least 0.5 in. from the edge of the specimen. Do not allow the contact point to touch the backing block or clamp bar.

**Table 12-1: Company pre-qualification testing of coating and application facility for coating System 1A (Replaces CSA Z245.20-14 Table 2)[#]**

| Test | Number of test specimens | CSA Z245.20-14 Test Method Clause | System 1A Acceptance Criterion |
|---|---|---|---|
| 24 h cathodic disbondment @ 65°C, 3.5 V | 3 | 12.8 | 4.5 mm maximum average radius on each specimen * |
| 48 h cathodic disbondment @ 65°C, 1.5 V | 3 | 12.8 | 4.5 mm maximum average radius * |
| 14 day cathodic disbondment @ 65°C, 1.5 V | 3 | 12.8 | 11.5 mm maximum average radius * |
| 28 day cathodic disbondment @ 20°C, 1.5 V | 3 | 12.8 | 7.0 mm maximum average radius [+] |
| 28 day cathodic disbondment @ 50°C, 1.5 V | 3 | 12.8 | 11.5 mm maximum average radius * |
| 28 day cathodic disbondment @ 65°C, 1.5 V | 3 | 12.8 | 13.5 mm maximum average radius * |
| 28 day cathodic disbondment @ 80°C, 1.5 V | 3 | 12.8 | 16.5 mm maximum average radius * |
| Cross section porosity | 3 | 12.10 | Rating 1-4 |
| Interface porosity | 3 | 12.10 | Rating 1-4 |
| 2.5° flexibility @ -30°C | 3 | 12.11 | No cracking |
| 1.5° flexibility @ -30°C | 3 | Clause 7.3.3.3.3 and 12.11 of this Specification | No cracking or no stretch or stress marks |
| 1.5 J impact resistance @ -40°C, -30°C, -10°C, 0°C, 20°C and 50°C | 3 at each temperature | 12.12 | No holidays |
| Thermal characteristics | 3 | 12.7 | CSA Z245.20-14 Table 1 and Table 4 |
| Adhesion: 24 h @ 75°C and 95°C | 3 at each temperature | 12.14 | Rating 1-3 on each specimen |
| Adhesion: 48 h @ 75°C | 3 | 12.14 | Rating 1-3 on each specimen |
| Adhesion: 28 days @ 75°C and 95°C | 3 at each temperature | 12.14 | Rating 1-3 on each specimen |

**Note:**

* The average for each specimen is determined and the three (3) averages are averaged to determine if the acceptance criterion is met.

[+] No individual reading shall exceed 8.0 mm.

[#] Any qualification re-tests to be completed will be at the discretion of the Company.

**Table 12-2: Company pre-qualification testing of coating and application facility for coating System 2B and 2C (Replaces CSA Z245.20-14 Table 6)#**

| Test | Number of test specimens | CSA Z245.20-14 Test Method Clause | System 2B & 2C Acceptance Criterion |
|---|---|---|---|
| 24 h cathodic disbondment @ 65°C, 3.5 V | 3 | 12.8 | 4.5 mm maximum average radius * |
| 48 h cathodic disbondment @ 65°C, 1.5 V | 3 | 12.8 | 4.5 mm maximum average radius * |
| 28 day cathodic disbondment @ 20°C, 1.5 V | 3 | 12.8 | 6.5 mm maximum average radius on each specimen |
| 28 day cathodic disbondment @ 65°C, 1.5 V | 3 | 12.8 | 13.5 mm maximum average radius * |
| 28 day cathodic disbondment @ 80°C, 1.5 V | 3 | 12.8 | 16.5 mm maximum average radius * |
| Cross section porosity | 3 | 12.10 | Rating 1-4 |
| 2.5° flexibility @ -30°C | 3 | Clause 7.3.3.3.3 and 12.11 of this Specification | No disbondment from steel and no cracking and/or no stretch or stress marks |
| 1.5° flexibility @ -30°C | 3 | Clause 7.3.3.3.3 and 12.11 of this Specification | No cracking and/or no stretch or stress marks |
| 3.0 J impact resistance @ -40°C, -30°C, -10°C, 0°C, 20°C and 50°C | 3 at each temperature | 12.12 | No holidays |
| Thermal characteristics | 3 | 12.7 | CSA Z245.20-14 Table 5 and Table 8 |
| Adhesion: 24 h @ 75°C and 95°C | 3 at each temperature | 12.14 | Rating 1-3 on each specimen |
| Adhesion: 48 h @ 75°C | 3 at each temperature | 12.14 | Rating 1-3 on each specimen |
| Adhesion: 28 d @ 75°C and 95°C | 3 at each temperature | 12.14 | Rating 1-3 on each specimen |
| Gouge test at -30°C and 50°C | 3 at each temperature | Clause 12.15 of this Specification | Maximum penetration depth of 508 µm (20 mils) |

**Note:**

* The average for each specimen is determined and the three (3) averages are averaged to determine if the acceptance criterion is met.

# Any qualification re-tests to be completed will be at the discretion of the Company.

## 13 VARIANCES

Any deviation shall follow the Company Management of Change (MOC) Variance Procedure (EDMS No. 7728702). External vendors must contact the Company Responsible Engineer or another authorized Company representative for variance approval.

## 14 ROLES AND RESPONSIBILITIES

Table 14-1 lists the roles and responsibilities required for the use of this Specification.

**Table 14-1: Roles and Responsibilities**

| Role | Responsibilities |
|---|---|
| Applicator | The Applicator is responsible for ensuring that the proper method is used to apply the FBE materials to the appropriate surface area. |
| Company Coating Inspector | The Company Coating Inspector is responsible for ensuring that the Applicator uses the proper method to apply the FBE materials to the appropriate surface area, and that the result meets the standards set forth by the Company in this Specification. |
| Responsible Engineer | The Responsible Engineer is accountable for ensuring that the plan set forth by the Applicator meets the standards set forth by the Company, and that resolution to any questions that arise from the use of this Specification meets the standards set forth by the Company. |
| Manufacturer | The Manufacturer is responsible for ensuring that the product produced for application is produced in accordance with the documentation that it provides to the Applicator. |

## 15 REFERENCES

This document relies on a number of references to regulation, industry codes and standards, general industry guidance as well as internal references. These documents are listed in Table 15-1, Table 15-2 and Table 15-3. Use the latest document revision, unless otherwise approved by TransCanada.

**Table 15-1: Regulatory References**

| Organization/Document No. | Title |
|---|---|
| Canadian Standards Association (CSA) | CSA Z245.20-14 Plant-applied external fusion bond epoxy coating for steel pipe |
| | CSA Z662 Oil and Gas Pipeline Systems |
| U.S. Department of Transportation (DOT), Code of Federal Regulations (CFR) | DOT 49 CFR 192 Transportation of Natural and Other Gas by Pipeline |
| | DOT 49 CFR 195 Transportation of Hazardous Liquids by Pipeline |

**Table 15-2: External Industry References**

| Organization/Document No. | Title |
|---|---|
| National Association of Corrosion Engineers (NACE) International | NACE SP 0394 Application, Performance, and Quality Control of Plant-Applied Single Layer Fusion-Bonded Epoxy External Pipe Coating |

**Table 15-3: Internal References**

| Document No. | Title |
|---|---|
| For this Specification, there are no specific Internal References | |

## 16 DOCUMENTATION AND RECORDKEEPING

All technical document submittal requirements are provided in the Vendor Technical Document Requirements List (VDRL) included with the proposal request or purchase order.

Due to the broad range of data types that may be required in support of this Specification, there are a number of repositories that may need to be utilized for documentation purposes. A summary of key data repositories appears in Table 16-1.

**Table 16-1: Documentation Requirements**

| Documentation Description | Repository / Link |
|---|---|
| Quality Documentation | Project Records |
| Test Reports and Certificates of Compliance | Project Records |

## 17 DOCUMENT HISTORY

| Rev. | | |
|---|---|---|
| 09 | **Description** | **Effective Date** |
| | This document is the new version of TES-COAT-FBE, updated in accordance with the CPG Integration. | 2017-Aug-01 |
| | **Rationale Statement** | **Responsible Engineer** |
| | This document was developed / revised in order to address the following requirements:<br>• CPG Integration | Aissa Van Der Veen, P. Eng. |
| | **Impact Assessment Summary** | **Document Owner** |
| | This Specification was revised to integrate the TransCanada and CPG documents. | Aissa Van Der Veen, P. Eng. |
| **Rev.** | | |
| 08 | **Description** | **Effective Date** |
| | This document is the new version of TES-COAT-FBE, updated in accordance with the documentation Streamlining initiative. | 2016-Nov-08 |
| | **Rationale Statement** | **Responsible Engineer** |
| | This document was developed / revised in order to address the following requirements:<br>• Streamlining of content to reflect the updated document collection of the coatings department | Aissa Van Der Veen |
| | **Impact Assessment Summary** | **Document Owner** |
| | This Specification was revised to streamline the documentation required for the Coatings group and to make it more easily accessible to those who use it. | Aissa Van Der Veen |

## 18 DESCRIPTION OF CHANGE

| Section | Description of Change |
|---|---|
| **Regulatory** | |
| N/A | N/A |
| **Industry Standards** | |
| N/A | N/A |
| **General** | |
| Update format and content | As a part of the Streamlining and Simplification process, this document has been reformatted and updated to reflect TransCanada template. |

## 19 APPROVALS

| APPROVALS | | |
|---|---|---|
| Originator:<br>Aissa Van Der Veen, P. Eng.<br>Welding and Materials Engineering | Signature | Date: June 27, 2017 |
| Reviewer:<br>Daniel Herpin, Manager<br>Corrosion Services | Signature | Date: June 27, 2017 |
| Reviewer:<br>Niteesha Falcon, P. Eng.<br>Welding and Materials Engineering | Signature | Date: June 27, 2017 |
| Responsible Engineer:<br>Aissa Van Der Veen, P. Eng.<br>Welding and Materials Engineering | Signature<br>Date: June 27, 2017 | PROFESSIONAL ENGINEER ALBERTA AISSA VAN DER VEEN<br>APEGA Permit to Practice P7100 |
| Management Endorsement:<br>James Ferguson, P. Eng., Manager<br>Welding and Materials Engineering | Signature | Date: June 27, 2017 |

## APPENDIX A PHOTOGRAPHS OF BEND TESTING EQUIPMENT

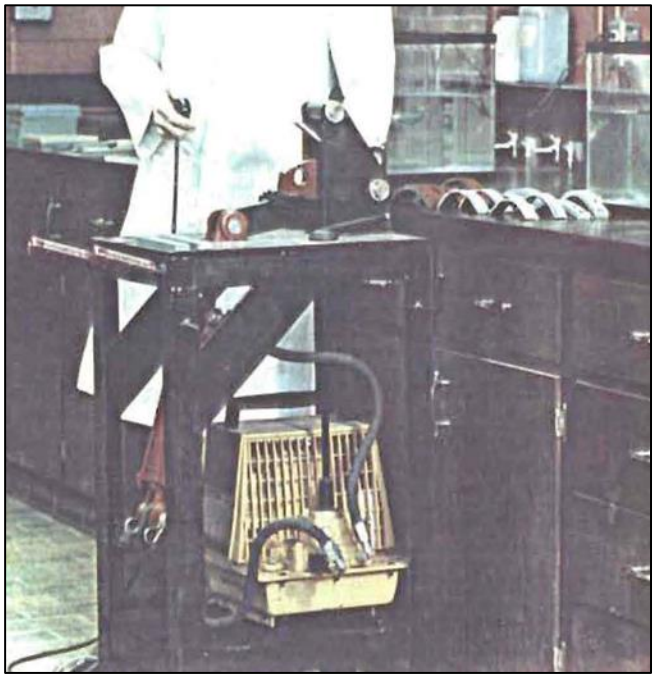

**Figure A-1: Bend Testing Equipment**

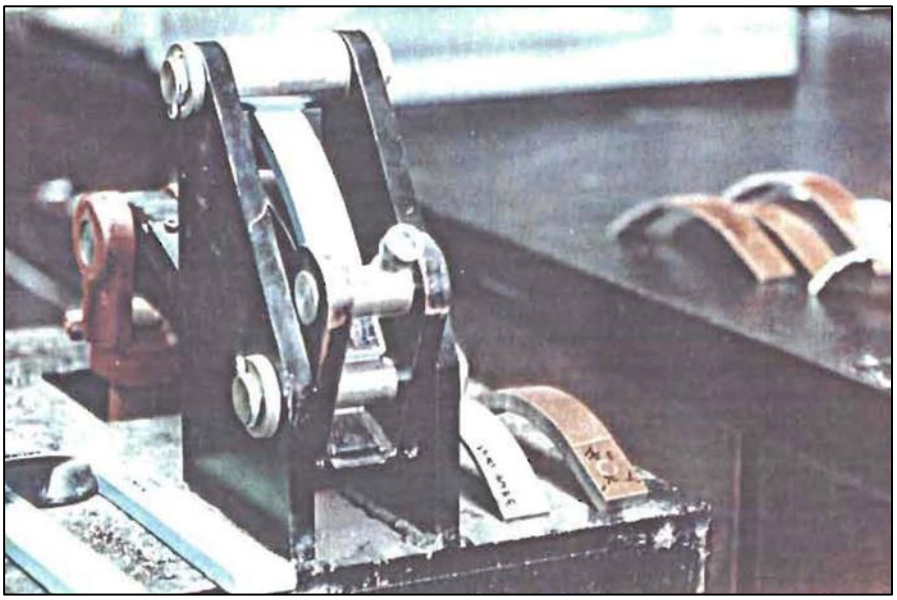

**Figure A-2 Close-Up of Bend Testing Equipment**

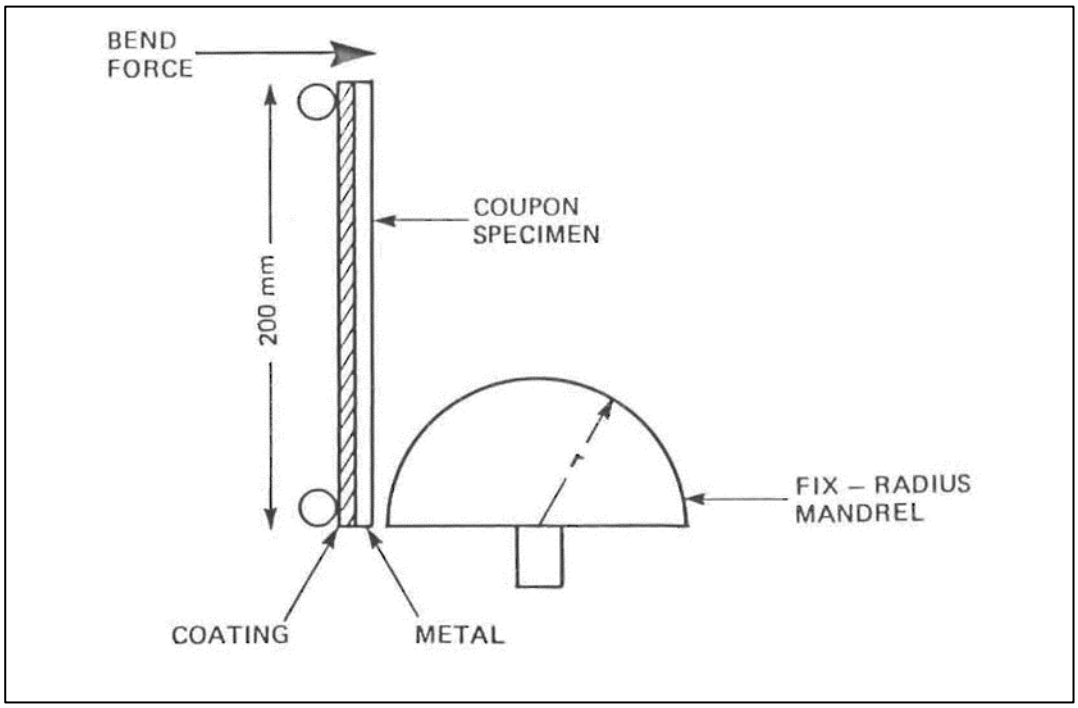


**Figure A-3 Mandrel Diagram**

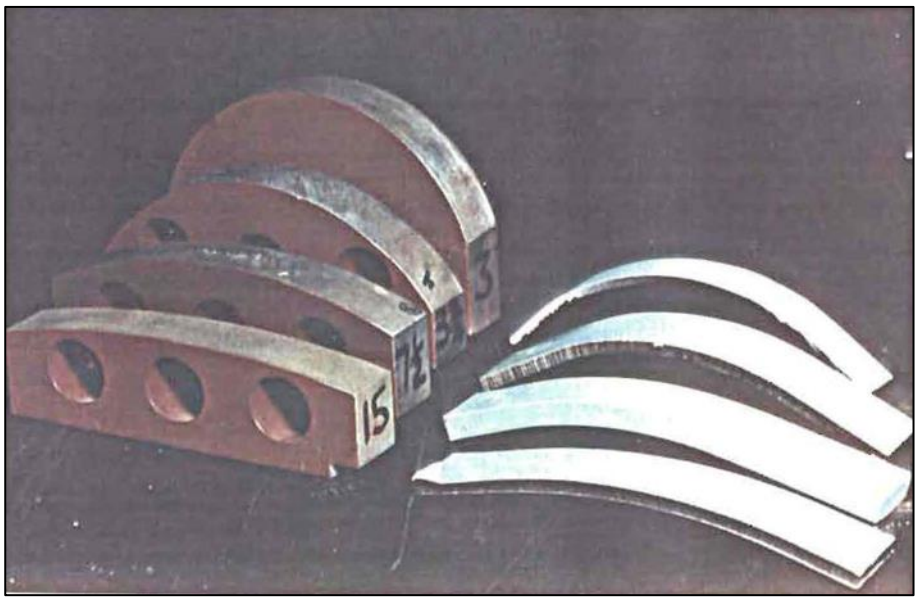


**Figure A-4 Mandrels**

**Figure A-5: Bend Test Perspective 1**

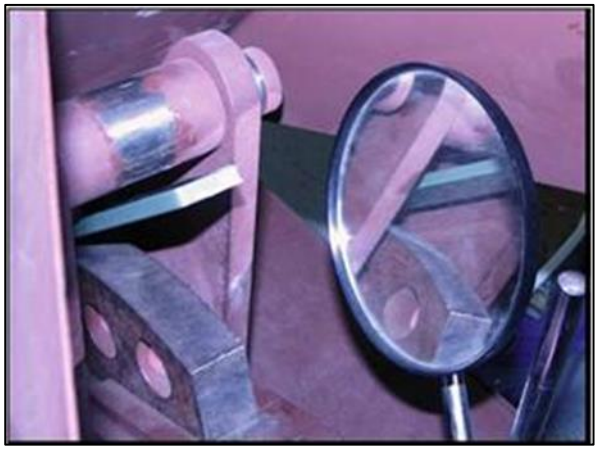

**Figure A-6: Bend Test Perspective 2**

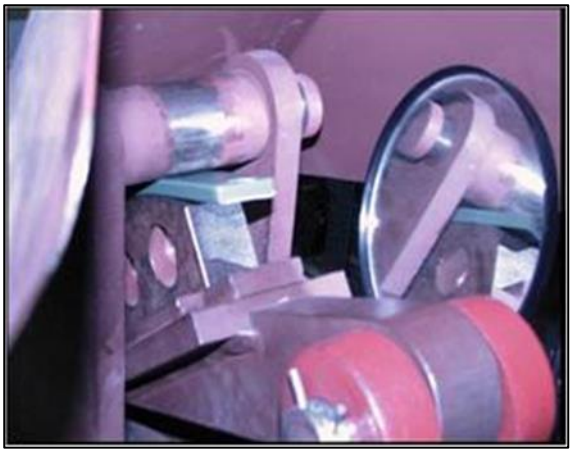

**Figure A-7: Bend Test Perspective 3**

**Figure A-8: Top View of Bend Testing Equipment**

## APPENDIX B PHOTOGRAPHS OF GOUGE TESTING EQUIPMENT


**Figure B-1: Gouge Testing Equipment**

## PURPOSE

This Standard provides key requirements for the non-destructive examination (NDE) of the welding of pipe and components, by identifying the applicable Specifications(s) and/or Procedure(s).

## SCOPE / APPLICABILITY

This Standard details the NDE Techniques used by the Company, their considerations for application and reporting requirements. This standard refers to the NDE of welds completed on pipe and piping components for new construction, maintenance, and repairs of existing facilities and examination conducted either in-plant, in-shop, or in-field. Each Specification and/or Procedure referenced in this document covers the minimum requirements for examination and review of examination results.

This Standard also applies to all pipelines, pipeline components, and facilities in Canada, the United States (U.S.), and Mexico.

This Standard applies to TransCanada's NDE program as it relates to the following techniques:

- Ultrasonic (UT)
  - Manual Ultrasonic Examination (UT/MUT)
  - Automated Ultrasonic Examination (AUT)
  - Phased Array Examination (PA)
- Radiographic Examination (RT) including X-Ray, Gamma, Computed (CR) and Digital (DR)
- Magnetic Particle (MT)
- Liquid Penetrant (PT)
- Visual Examination (VT)

The Responsible Engineer shall be contacted for clarification if needed.

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# 1 CONTENT FRAMEWORK

The content framework in Figure 1-1 provides the general structure for the material as applicable to this Standard. This framework represents the key requirement categories outlined in Section 2.

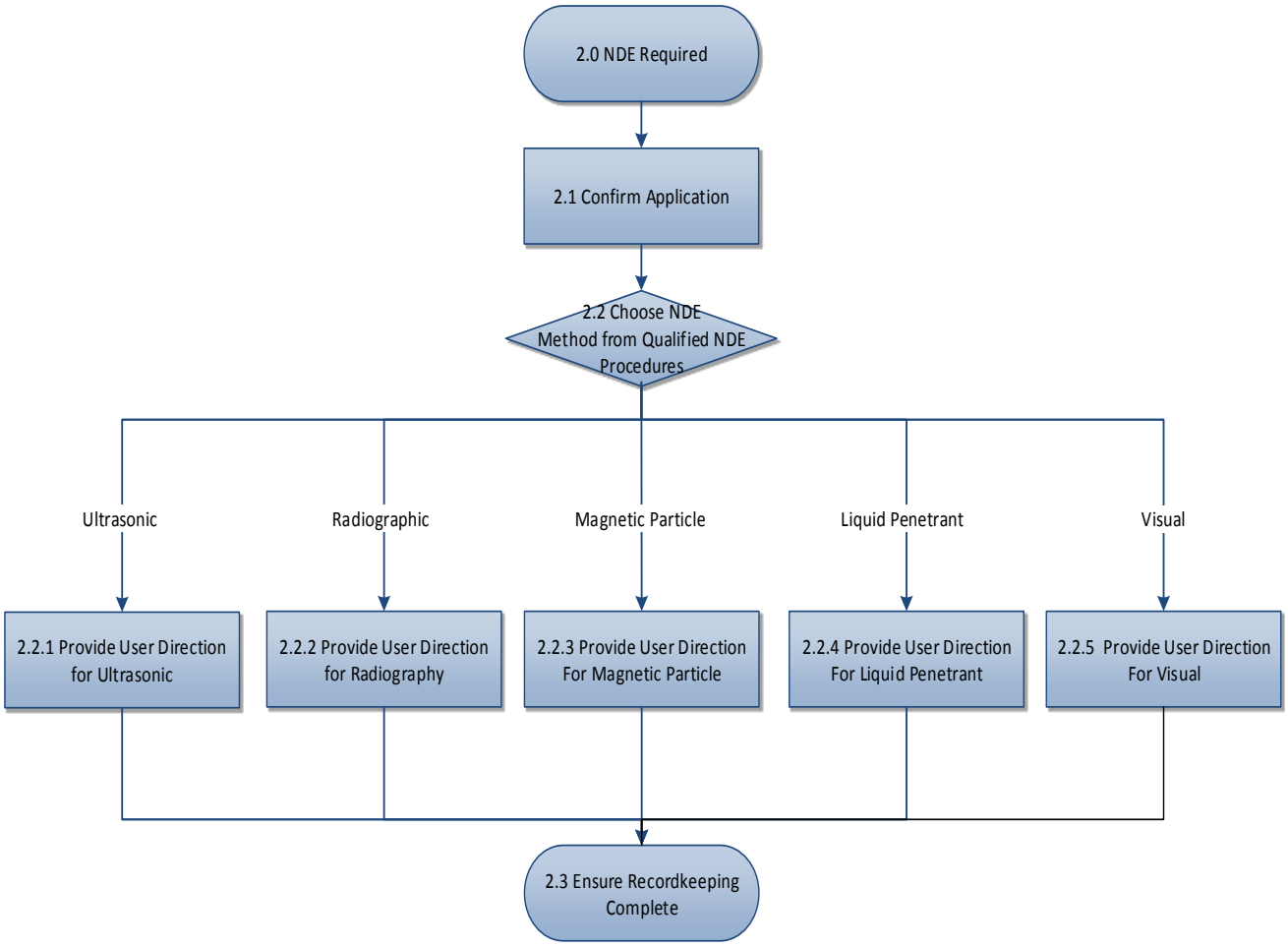


**Figure 1-1: Content Framework**

## 2 NDE REQUIREMENTS

The process outlined in this Standard is initiated when the need for non-destructive examination of welding is identified.

### 2.1 Confirm Application

A qualified individual will select the NDE technique based on five primary factors:

- Location of NDE application (see Table 2-1)
- The nature and type of the weld (see Table 2-2)
- The NDE method considerations (see Table 2-3)
- The scope of the project (described in the following tables)

The type of application determines the most appropriate NDE type. Table 2-1 defines the NDE type and corresponding application location.

**Table 2-1: Allowable NDE Methods Based on Application**

| Application | Ultrasonic Examination (UT) | Automated Ultrasonic Examination (AUT) | Radiographic Examination (RT)[1] | Magnetic Particle Examination (MT) | Liquid Penetrant Examination (PT) | Phased Array (PA) | Visual Examination (VT) |
|---|---|---|---|---|---|---|---|
| Fabrication, Shop | ✓[2] | X | ✓ | ✓ | ✓[4] | ✓[5] | ✓ |
| Fabrication, Field | ✓[2] | X | ✓ | ✓ | ✓[4] | ✓[5] | ✓ |
| Facility | ✓[2] | ✓[3] | ✓ | ✓ | ✓[4] | ✓[5] | ✓ |
| In-Service Welding | ✓ | X | ✓ | ✓ | ✓[4] | ✓[5] | ✓ |
| Pipeline | ✓ | ✓ | ✓ | ✓ | ✓[4] | ✓[5] | ✓ |

**Notes:**

[1] Includes Computed Radiography (CR) and Digital Radiography (DR).

[2] Not typically utilized as a standalone application, more of a supplementary method as needed.

[3] AUT shall only be utilized on known pipe materials which calibration blocks have been created for. Pipe to pipe applications only.

[4] PT Inspection shall be utilized in place of MT for stainless steel applications.

[5] PA inspection requests shall be subject to conditions and approval by Materials and Welding Engineering.

### 2.2 Choose NDE Method from NDE Specifications

The most appropriate type of NDE is then determined according to the nature and type of the weld. Table 2-2 defines the typical primary NDE techniques (or combination of) for different weld techniques.

**Table 2-2: NDE Determination Method**

| Welding Technique | Typical Primary NDE Method | Possible Combinations |
|---|---|---|
| Gas Metal Arc Welding (GMAW) | • UT (AUT only)<br>• Do not use AUT in a fabrication shop | • Supplement AUT with MUT, MT and RT, depending on the project scope (pipeline to facility) |
| Shielded Metal Arc Welding (SMAW) | • AUT is the preferred application if large (over 15 km) quantities of welds require examination and wall thickness is greater than 6.4 mm (0.250 in)<br>• RT is the preferred application if small (under 15 km) quantities of welds require examination or wall thickness is below 6.4 mm (0.250 in) | • Use AUT or RT in combination with MT and MU, depending on the project scope (pipeline to facility) |
| Flux Cored Arc Welding (FCAW) | • AUT is the preferred application if large (over 15 km) quantities of welds require examination and wall thickness is greater than 6.4 mm (0.250 in)<br>• RT is the preferred application if small (under 15 km) quantities of welds require examination or wall thickness is below 6.4 mm (0.250 in) | • Use AUT or RT in combination with MT and MU, depending on the project scope (pipeline to facility) |

In order to choose the correct combination of NDE methods, it is important to be aware of the pros and cons for each method, as well as the type of anticipated anomalies.

Table 2-3 defines some of the considerations.

**Table 2-3: NDE Method Considerations**

| NDT Type | Pros | Cons |
|---|---|---|
| AUT | • Provides through-thickness position and the dimensions of imperfections in the vertical and circumferential plane<br>• Most economic process for heavier wall, larger diameter pipe<br>• Recorded and auditable inspection data<br>• Most effective technique for planar weld flaws (lack of fusion and cracks)<br>• Instant results enabling immediate weld quality assessment<br>• High productivity able to match construction production rates<br>• Can work within any vicinity of public and or workers | • Considerable cost and time required for initial setup<br>• Limited to wall thicknesses greater than 6.4 mm (0.250 in.) for factory bevels and 7.2 mm (0.283 in.) for GMAW bevels<br>• Highly trained technicians required to perform the work<br>• Weld preparation required—i.e., 10-13 cm (4-5 in) of pipe coating, weld spatter and seam removal on either side of girth weld<br>• Specialized technique with limited approved vendors who can supply this service |
| MUT (supplementary process) | • Provides through-thickness position and the dimensions of imperfections in the vertical and circumferential plane<br>• Typically, a one-man crew can perform the work | • No recorded data, limiting audit function to procedural and reporting review<br>• Typically, only utilized as supplementary application to AUT or RT |
| RT (X-ray and Gamma Ray) | • Very little setup time and cost required to prepare for a project<br>• Application can be made by most Company approved NDE vendors<br>• Recorded and auditable inspection data allow for good detection of volumetric flaws | • Cannot provide through-thickness dimensions of imperfections<br>• Circumferential positioning and flaw classification only<br>• Significantly reduced productivity as the weld thickness increases or if the weld is inspected externally<br>• Cannot achieve instant results due to process, safety, and proximity limitations<br>• Health and safety risks associated with use of radiation<br>• Overlooked associated consumables can add up to significant additional costs<br>• Storage costs for film developed throughout a project are significantly higher than AUT data |

| NDT Type | Pros | Cons |
|---|---|---|
| Computed Radiography (CR) | • Ability to manipulate image resolution compared to standard radiography<br>• Digital files enable remote third party reviews of films if required<br>• Good for detecting volumetric flaws<br>• Reduced film costs | • Health and safety risks associated with use of radiation<br>• Cannot achieve instant results due to process, safety, and proximity limitations<br>• Cannot provide through-thickness dimensions of imperfections<br>• Circumferential positioning and flaw classification only<br>• Significantly reduced productivity as the weld thickness increases or if the weld is inspected externally<br>• Approval and assessment required by the Company prior to implementation |
| Digital Radiography (DR) | • Fastest RT method<br>• Ability to manipulate image resolution compared to standard radiography<br>• Digital files enabling remote third party reviews of films if required<br>• Good for detecting volumetric flaws<br>• Reduced film costs<br>• Reduced radiation exposure in comparison to standard RT methods<br>• Increased productivity in comparison to other RT applications | • Currently only applicable to pipeline construction projects<br>• Health and safety risks associated with use of radiation<br>• Cannot achieve instant results due to process, safety, and proximity limitations<br>• Cannot provide through-thickness dimensions of imperfections<br>• Circumferential positioning and flaw classification only<br>• Typically, a cumbersome piece of equipment, which could limit tight space applications<br>• Approval from Materials and Welding Engineering required prior to use |
| MT/MPI | • Ideal for surface and surface breaking flaws<br>• Rapid and easy to interpret | • Cannot easily detect buried flaws<br>• Cannot detect depth of flaws<br>• Limited to specific weld inspection applications as defined in Company Specifications |
| PT/LPI | • Good for surface breaking flaws<br>• Rapid and easy to interpret | • Cannot detect buried flaws<br>• Cannot detect depth of flaws<br>• Limited to specific weld inspection applications as defined in Company Specifications |

| NDT Type | Pros | Cons |
|---|---|---|
| PA | • Provides through-thickness position and the dimensions of imperfections in the vertical and circumferential plane<br>• Most economic process for heavier wall, larger diameter pipe<br>• Recorded and auditable inspection data<br>• Most effective technique for planar weld flaws (lack of fusion and cracks)<br>• Instant results enabling immediate weld quality assessment<br>• Works within any vicinity of public and or workers | • High training requirement because technique requires more technical knowledge than traditional UT<br>• Considerable time required for initial setup<br>• Weld preparation required—i.e., 8-13 cm (3-5 in) of pipe coating, weld spatter and seam removal on either side of girth weld<br>• Specialized technique with limited approved vendors who can supply this service<br>• Suitable as a standalone application for pipe to pipe configurations only at this stage<br>• Approval from Materials and Welding Engineering required prior to use |
| VT | • Easy to perform, simple, and does not require sophisticated equipment (fiberscopes, borescopes, magnifying glasses, and mirrors) | • Only able to detect imperfections visible to the human eye |

### 2.2.1 User Direction for Ultrasonic Examination (UT)

There are three main UT techniques used by the Company. Table 2-4 provides the names of the Specifications used for each technique.

**Table 2-4: Ultrasonic Techniques**

| Technique | Instructional Document |
|---|---|
| Automated Ultrasonic Examination (AUT) | • TES-NDT-UT (for Canada) (EDMS No. 1001829033)<br>• TES-UT-API (for the US and Mexico) (EDMS No. 1001828660) |
| Manual Ultrasonic Examination (MUT) | • TES-NDT-UT (for Canada) (EDMS No. 1001829033)<br>• TES-UT-API (for the US and Mexico) (EDMS No. 1001828660) |
| Phased Array (PA) | • TES-NDT-PA (for Canada, US and Mexico) (EDMS No. 9219103) |

### 2.2.2 User Direction for Radiographic Examination (RT)

There are three main RT techniques used by The Company. Table 2-5 provides the names of the Specifications used for each technique.

**Table 2-5: Radiographic Techniques**

| NDE Technique | Instructional Document |
|---|---|
| X-Ray/Gamma | • TES-NDT-RT (for Canada) (EDMS No. 3671368)<br>• TES-RT-API (for the US and Mexico) (EDMS No. 4472888) |

| NDE Technique | Instructional Document |
|---|---|
| Digital Radiography (DR) | • TES-NDT-RT (for Canada) (EDMS No. 3671368)<br>• TES-RT-API (for the US and Mexico) (EDMS No. 4472888) |
| Computed Radiography (CR) | • TES-NDT-RT (for Canada) (EDMS No. 3671368)<br>• TES-RT-API (for the US and Mexico) (EDMS No. 4472888) |

### 2.2.3 Direction for Magnetic Particle Examination (MT)

TransCanada has not identified any requirements that are incremental to CSA Z662, API 1104, or ASME, as applicable, for this Standard.

### 2.2.4 Direction for Liquid Penetrant Examination (PT)

TransCanada has not identified any requirements that are incremental to CSA Z662, API 1104, or ASME, as applicable, for this Standard.

### 2.2.5 Direction for Visual Examination (VT)

Visual examination is the responsibility of the Welding group. For information on visual examination, refer to TEP-NDT-VT Visual Examination (CDN-US-MEX) (EDMS No. 7381161).

## 2.3 Ensure Recordkeeping Complete

Once examination is complete, any required documentation must be updated regarding the completed NDE. This information should be added to TEP-NDT-REC Non-Destructive Examination Records Management (CDN) (EDMS No. 3749393).

# 3 VARIANCES

Any deviation must follow the appropriate TransCanada Management of Change (MOC) Variance Procedure (EDMS No. 7728702).

# 4 ROLES AND RESPONSIBILITIES

Table 4-1 outlines the roles and responsibilities required for the use of this Standard.

**Table 4-1: Roles and Responsibilities**

| Role | Responsibilities |
|---|---|
| NDE Technician | • Responsible for the completion of the NDE and the interpretation of the results. |
| NDE Team within Welding and Materials Engineering | • Accountable for the examination and inspection of pipelines and pipeline components. |
| Welding Team within Welding and Materials Engineering | • Responsible for informing the NDE team of welding projects so that NDE can be coordinated.<br>• Accountable for visual Inspections of welds. |

## 5 TRAINING AND QUALIFICATIONS

Training and qualification requirements are as prescribed in applicable specifications, codes, and regulations.

## 6 SAFETY CONSIDERATIONS

No incremental Safety Considerations are identified for this Standard.

## 7 ENVIRONMENTAL CONSIDERATIONS

No incremental Environmental Considerations are identified for this Standard.

## 8 GLOSSARY

Definitions related to this Standard can be found in Appendix A.

## 9 REFERENCES

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

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 9-1.

**Table 9-1: External and Internal References**

| Document No. | Title |
|---|---|
| **Legal Requirements** | |
| For this Specification, there are no specific legal requirements. | |
| **Industry Codes and Standards** | |
| API 1104 | Welding of Pipelines and Related Facilities |
| ASME V | Boiler and Pressure Code – Section V – Non-Destructive Examination |
| ASME B31.3 | Gas Transmission and Distribution Piping Systems |
| CSA Z662 | Oil and Gas Pipeline Systems |
| **Internal References – Documents that Reference this Standard** | |
| N/A | N/A |
| **Internal References – Documents Referenced by this Standard** | |
| EDMS No. 3671368 | TES-NDT-RT Radiographic Examination of Welds Specification (CDN) |

| Document No. | Title |
|---|---|
| EDMS No. 4472888 | TES-RT-API Radiographic Examination of Welds Specification (US-MEX) |
| EDMS No. 1001829033 | TES-NDT-UT Ultrasonic Examination of Girth Welds Specification (CDN) |
| EDMS No. 1001828660 | TES-UT-API Ultrasonic Examination of Girth Welds Specification (US-MEX) |
| EDMS No. 3749393 | TEP-NDT-REC Non-Destructive Examination Records Management (CDN) |
| EDMS No. 9219103 | TES-NDT-PA Phased Array & TOFD Inspections of Welds & Materials (CDN-US-MEX) |

## 10 DOCUMENTATION AND RECORDKEEPING

Documentation created through the use of this Standard shall be indexed in the Records Management Database, and filed in accordance with TEP-NDT-REC Non-Destructive Examination Records Management (CDN) (EDMS No. 3749393). These documents may include but are not limited to: Radiographic films, Automated Ultrasonic Scans, Daily Radiographic/Ultrasonic Reports, Liquid Penetrant Examination Interpretation Reports, and Magnetic Particle Examination Interpretation Reports.

## 11 DOCUMENT HISTORY

| Rev. | | |
|---|---|---|
| 00 | **Description** | **Effective Date** |
| | New document developed as part of Engineering Standards Streamlining Process. | 2016-Nov-01 |
| | **Rationale Statement** | **Responsible Engineer** |
| | This document was developed in order to address the following requirements:<br>• Provide a standard for the NDE method determination process | Robert Lazor, P.Eng. |
| | **Impact Assessment Summary** | **Document Owner** |
| | This standard was created to streamline the documentation required for the NDE group and to make it more easily accessible to those using the underlying specifications. | Robert Lazor, P.Eng. |

## 12 DESCRIPTION OF CHANGE

| Section | Description of Change |
|---|---|
| **Regulatory** | |
| N/A | N/A. |
| **Industry Standards** | |
| N/A | N/A. |
| **General** | |
| N/A | This Standard is a new document. |

## 13 APPROVALS

| APPROVALS | | |
|---|---|---|
| Originator:<br>Jason Althouse, Senior NDE Technologist,<br>Welding and Materials Engineering | Signature | Date: 2016-Nov-01 |
| Reviewer:<br>Salvatore Delisi, Senior Welding Technologist,<br>Welding and Materials Engineering | Signature | Date: 10/25/16 |
| Responsible Engineer:<br>Robert Lazor, P.Eng.,<br>Welding and Materials Engineering | Signature<br>Date: 1 Nov 2016 | PROFESSIONAL ENGINEER ALBERTA<br>APEGA Permit to Practice P7100 |

## APPENDIX A TERMS AND DEFINITIONS

| Terms | Definitions |
|---|---|
| **Company** | TransCanada including their engineering agencies, inspectors and other authorized representatives. |
| **Vendor** | Any outside source hired by the Company to complete work |
| **PT (Liquid Penetrant Inspection)** | A method of inspection that utilizes the capillary action of open to surface defects and is used primarily for non-ferrous materials (i.e. Stainless Steel). |
| **MT (Magnetic Particle Inspection)** | A method of inspection that uses flux leakage to detect surface and sub-surface discontinuities on ferrous materials |
| **UT (Ultrasonic Inspection)** | A method of inspection that utilizes ultrasonic waves to detect discontinuities within the materials being inspected and is hand manipulated |
| **AUT (Automated Ultrasonic Inspection)** | Automated zonal ultrasonic inspection of pipeline girth welds that records and stores data in a digital format. This method is driven with an automated or semi-automated scanner. |
| **PA (Phased Array Ultrasound)** | Phased array inspection utilizes electronically manipulated angles of ultrasonic waves that can record and store data in a digital format. This process can be automated or hand manipulated. |
| **TOFD (Time of Flight Diffraction)** | Time of Flight Diffraction is an ultrasonic method that floods the inspection material with sound for a full volumetric inspection. This method is driven with an automated or semi-automated scanner. |
| **RT (Radiography)** | Radiography is an imaging technique that uses electromagnetic radiation to view the material being inspected. This method produces a film or digitized image record. |

## PURPOSE

This Specification details the requirements for the radiographic examination of welds.

## SCOPE / APPLICABILITY

This Specification establishes the requirements for radiographic examination of procedure qualification welds, welder performance qualification welds, and production welds. This Specification also details equipment requirements, operator and radiographic procedure qualification requirements, and quality and reporting requirements for the radiographic examination of welds.

This Specification applies to welds in natural gas and hazardous liquid pipeline applications for the Company (as well as affiliates) in United States and Mexico. Refer to TES-NDE-RT Radiographic Examination of Welds Specification (CDN) (EDMS No. 3671368) for requirements for Canada.

The Responsible Engineer shall be contacted for clarification if needed.

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# 1 CONTENT FRAMEWORK

The content framework in Figure 1-1 provides the general structure for the material as applicable to this Specification. This framework represents the key requirement categories outlined in Section 2.

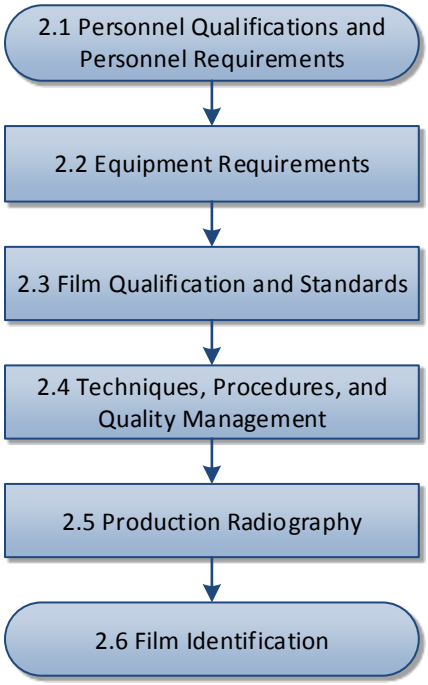


**Figure 1-1: Content Framework**

## 2 REQUIREMENTS

All radiographic examination of welds shall conform to the following requirements:

- Notwithstanding the requirements of this specification, radiographic examination shall comply with the requirements of the latest approved edition of API 1104 or ASME V, as applicable.
- All mainline girth welds, tie-in welds, replacement welds, double joint welds, and repair welds completed using manual or semi-automatic welding processes may be radiographed for 100% of the circumference in accordance with this Specification and assessed in accordance with API 1104 Section 11 or ASME V, as applicable. At the discretion of the Company these welds may alternatively be identified for ultrasonic examination.
- Only Company approved radiographic techniques shall be used.
- The Company shall have the right to non-destructively examine all welds during and after welding to ensure compliance with the standards of acceptability detailed below in this section.
- The Company shall also have the right to order removal of any weld for destructive or other examination. The Company is the final authority for the acceptance of welds.
- The general standards of acceptability for discontinuities located by all non-destructive examination (NDE) methods, including visual examination, are defined by API 1104 or ASME V, as applicable; observed defects shall be reported on Company approved Daily Radiographic Reports. Defects such as crater cracks, weld metal, heat-affected zone or base metal cracks are unacceptable, regardless of size or location.

### 2.1 Personnel Qualifications and Personnel Requirements

This section will outline the requirements for personnel qualifications and Contractor responsibilities.

#### 2.1.1 Personnel Requirements

The Contractor shall provide a minimum of two personnel to perform radiography. One of the personnel shall be:

- A technical supervisor (if required by the Contract); or,
- As a minimum requirement, a Level II or Level III radiographer designated as a Technical Lead Hand who shall work closely with the Company Senior Welding Inspector and/or the NDE Inspector. The Technical Supervisor or Technical Lead Hand shall be approved by the Company.

The Contractor shall assign a Level II or Level III radiographer to each radiographic inspection unit. A Level II or Level III radiographer engaged by the Contractor shall be responsible for final film interpretation and reporting.

The Contractor may provide Level I personnel to assist in the radiographic operation under the direct supervision of a Level II or III radiographer. The Level I radiographic personnel shall not interpret radiographic film nor independently perform radiographic exposure operations or sign reports.

The Contractor shall ensure that each crew has, in their immediate possession, a complete copy of the current applicable Code(s)/Specification(s)/Standard(s).

## 2.2 Equipment Requirements

The radiographic units required for NDE shall be provided by the Contractor.

For pipeline projects, each of the radiographic units shall be classified as mainline, mini-mainline, tie-in, or repair. All radiographic units shall be equipped with;

- Self-contained vehicles complete with climate-controlled darkrooms for film processing and drying.
- Mainline and mini-mainline units shall be equipped with at least one self-propelled crawler (see Table 2-3, row 2), an experienced crawler operator, and other material and equipment required to expose, develop and interpret radiographs at a rate sufficient to keep up with the welding rate set by the Company or Pipeline Construction Contractor.
- Tie-in and repair units shall be equipped with X-ray tubes or Iridium 192 isotopes. The radiation type shall be defined by the Contractor in the bid and shall be subject to agreement by the Company.
- Cobalt 60 sources shall not be used with this Specification.
- Isotopes other than Iridium 192 (i.e. Selenium) shall be subject to Company approval before use.

The Contractor shall also have available on each spread, sufficient:

- Spare parts (including a complete working spare crawler when radiography of mainline girth welds is included in the scope of work), film, chemicals, and other consumables to ensure the continuance of work without interruption or delays; and
- Equipment, consumables, and qualified personnel as to provide for inspection of welds or pipe by means of liquid penetrant examination, magnetic particle examination, and ultrasonic thickness examination.

The condition and maintenance of the Contractor's radiographic equipment shall be subject to Company examination and approval. Supplies, consumables and necessary stand-by equipment shall be on hand to ensure that construction progress shall not be delayed.

## 2.3 Film Qualifications and Standards

The following sections outline the qualifications and standards for film including film type, radiographic quality, procedure and technique qualifications, and test radiographs.

### 2.3.1 Film Type

The Company shall approve the brand and type of radiographic film proposed by the Contractor; this list of approved brands is available in Table 2-1. These films and their application do not require further Company approval, providing the required sensitivity level is met during the qualification of the technique and during production radiography. Film classification shall be in accordance with ISO 11699-1.

Alternatively, wide latitude films such as the Agfa “Structurix Wide Latitude Film” are acceptable (with prior Company approval). The use of alternate brands and types is not permitted without prior written Company approval.

**Table 2-1: Acceptable Film Types**

| Gamma (Iridium 192) | X-Ray |
|---|---|
| Kodak* DR-50, M100, MX125 | Kodak* DR-50, M100, MX125, T200 |
| .Agfa Gevaert** D2, D3, D4 | Agfa Gevaert **D2, D3, D4, D5 |
| Fuji IX25, IX50 | Fuji IX25, IX50, IX80 |
| **Notes:**<br>*Kodak manufactures film under the trademark “Kodak Industrex”.<br>**Agfa Gevaert manufactures film under the trademark “Structurix”. | |

### 2.3.2 Radiographic Quality

Film shall be chosen to provide good definition, contrast, latitude, and of sufficient width as to provide, where practicable, at least 1 inch of coverage on each side of the weld cap. In situations where 1 inch is not achievable, the minimum distance between the cap edge and the edge of the film shall not be less than 0.250 inch.

Films shall be exposed so that a film density throughout the area of interest shall fall within the ranges provided in Table 2-2. The area of interest shall include the full welded area and extend out 0.250 inch from either side of the cap to include the heat-affected zone (HAZ).

The base density of the unexposed film shall be checked at least once per day and shall be documented with the following information:

- date
- film brand/type
- NDE technician name
- measured Hurter and Driffield (H&D) information permanently marked on the filmstrip itself and recorded on a log or daily report to be maintained for the project

**Table 2-2: Acceptable Density Ranges**

| Transition Welds | Unexposed density | Localized area not exceeding 50.8mm |
|---|---|---|
| 2.0 – 4.0 H&D | ≤ 0.30 H&D | 1.8 – 4.2 H&D |

### 2.3.3 Radiographic Procedure and Technique Qualification

A written procedure for the radiographic technique shall be established by the Contractor. Each radiographic technique shall be qualified by the Contractor on the first production weld available, prior to the start of production radiography. Radiographic technique qualifications shall also be performed if any of the following variables change:

- With any film change (i.e. Agfa to Kodak, Agfa D4 to Agfa D3)
- Type of radiation (X-Ray or Gamma)
- Radiographic exposure geometry (SWSI, DWSI, DWDI)
- Type of material being radiographed (i.e. carbon steel to stainless)
- Radiographer
- Project

As a minimum, the written radiographic procedure and related technique shall address all of the requirements of API 1104 or ASME V, as applicable, and include a description of the variables listed below. Changes to these variables may be subject to Company approval, provided the radiographic quality detailed in 2.3.2 of this Specification is maintained. However, the Company reserves the right to require re-qualification of a radiographic procedure or technique if any of the variables are changed or if any doubt exists regarding the ability of the procedure to produce an acceptable radiograph.

- Type of material being radiographed
- Joint bevel design
- Radiographic method e.g., single-wall or double-wall exposure
- Material thickness range for which the procedure is suitable
- Type of radiation to be used with details of effective source size or x-ray equipment voltage
- Object to film distance (OFD), Source or focal spot to film distance (SFD or FFD), Geometric Unsharpness Factor (Ug Factor), and Radiation angle with respect to the weld and film
- ASTM/ISO IQI (type of material, identification of ASTM or ISO set, essential wire, diameter/number and location)
- Position of radiation source (external or internal)
- Type, thickness, and position of intensifying screens and filters

- Sketch showing the geometric arrangement for the production of the radiographs, showing minimum source to film distance, and radiation angle with respect to the weld
- Film type and brand
- Length and width
- Number of films per weld
- Exposure conditions in milliamperes minutes or curie minutes
- The x-ray voltage or the input voltage and amperage
- Exposure time;
- Processing time and temperature for development
- Stop bath or rinse, fixing, washing and drying
- Identify whether manual or automatic
- Density (minimum and maximum)
- Sensitivity (%)
- Heat shields—material, thickness, and the distance from the film side of the heat shield to the pipe surface.

For each specific technique, the exposure conditions and radiographic quality achieved shall be recorded on a Company approved form or Company provided "Radiographic Examination Procedure Qualification Form F" (EDMS No. 8732529).

### 2.3.4 Test Radiograph Requirements

The radiographic quality achieved with the test radiograph must meet the requirements of this Specification. Requirements for the quality of test radiographs shall apply equally to exposures produced using both X-radiation and gamma-radiation.

The qualification test radiograph shall be reviewed and approved by the Company representative or inspector. The written procedure and test radiographs will be evaluated by the Company on the following basis:

- Film quality (e.g., fog level, handling and processing irregularities, density, sensitivity, definition, contrast and compliance with radiographic quality standards set forth in Section 2.3.2)
- Identification system
- Technique and set up
- Adequacy of the written descriptions and shooting sketches

## 2.4 Techniques, Procedures, and Quality Management

This section will describe the procedures, techniques, and quality management requirements for radiographic examination of girth welds.

### 2.4.1 Techniques

The NDE technique to be used is determined by the type of weld and the thickness of the pipe. Table 2-3 details the types of weld, pipe thickness, and the appropriate technique to be used.

**Table 2-3: NDE Techniques Based on Weld Type and Pipe Thickness**

| Row # | Weld Description and/or Pipe Thickness | NDE Technique Description[1] |
|---|---|---|
| 1 | For pipe diameters > NPS 24 and/or thickness > 0.500inches (12.7 mm) | • X-ray tubes shall have a minimum rating of 300 kV and 3 mA.<br>• When Iridium 192 sources are used, the curie strength for production radiography should not be less than:<br>▪ 30 curies for pipe diameters larger than NPS 8 but smaller than NPS 16, and<br>▪ 50 curies for pipe diameters NPS 16 and larger. |
| 2 | Mainline girth welds on pipe with diameters of ≥ NPS 16 | • Shall be radiographed using a true radial beam X-ray crawler and single-wall exposure, single wall viewing (SWE/SWV) technique.<br>• When a true radial beam X-ray tube is not available, permission is required from the Company to substitute a directional beam X ray tube.<br>• Alternative radiographic techniques may be reviewed on a per contract basis to accommodate project scope. |
| 3 | Assembly girth welds on pipe with diameters of ≥ NPS 16 | • Shall, wherever practicable, be radiographed using X-ray or Iridium 192 gamma radiation and SWE/SWV technique.<br>▪ Where this cannot be achieved, the weld may be radiographed using double wall exposure, single wall viewing (DWE/SWV) X-ray or Iridium 192 gamma radiation technique. |
| 4 | Mainline girth welds on pipe with diameters of ≥ NPS 8 but < NPS 16 | • Shall be radiographed using DWE/SWV X-ray or Iridium 192 gamma radiation techniques, alternatively, a SWE/SWV technique utilizing an Iridium 192 gamma crawler may be used. |
| 5 | Assembly girth welds on pipe with diameters of ≥ NPS 8 but < NPS 16 | • Shall be radiographed using the DWE/SWV X-ray or Iridium 192 gamma radiation techniques, or the SWE/SWV Iridium 192 gamma radiation technique. |
| 6 | Assembly welds on pipe with diameters of ≥ NPS 2 but < NPS 8 | • Shall be radiographed using the DWE/SWV Iridium 192 gamma radiation technique.<br>▪ When this cannot be achieved due to quality concerns, welds NPS 3 and smaller may be radiographed using DWE/DWV Iridium 192 gamma radiation technique.<br>▪ Note: For ≤ NPS 4, it may be necessary to use a finer grain film to achieve the required sensitivity. |

| Row # | Weld Description and/or Pipe Thickness | NDE Technique Description[1] |
|---|---|---|
| 7 | Assembly welds on pipe with diameters of < NPS 2 | • Shall be radiographed using the DWE/DWV Iridium 192 gamma radiation technique.<br>• Shall be inspected using either the elliptical or superimposed DWDI techniques.<br>• When these techniques are selected a source side image quality indicator (IQI) must be used.<br>• The IQI selection shall be based on two times the nominal pipe wall thickness for the elliptical technique, and two times the weld thickness for the superimposed technique.<br>• For the elliptical technique two exposures 90 degrees apart shall be made and for the superimposed technique three exposures 60 or 120 degrees apart shall be made.<br>• Where practical, the source to object distance for DWDI radiographs shall be a minimum of ten (10) pipe diameters distance. |
| 8 | Pipeline tie-in welds, replacement welds, repair welds, completed using manual or semi-automatic welding processes | • May be radiographed using X-ray or Iridium 192 gamma radiation. The radiation source should be selected with consideration to the material thickness and latitude required to radiograph welds between materials of different thicknesses. |
| 9 | Self -Shielded Arc Weld (FCAW) | • Requires a specific Company approved radiographic procedure with consideration to the detection of Barium slag and its sensitivity to the energies of radiation used.<br>• Radiation energy shall be 50 curies or greater for gamma isotopes, or X-ray machine having a rated capacity of 300Kv or greater. |
| 10 | Transition Welds | • For transition welds between pipes of different wall thicknesses where the density requirements of Section 2.3.2 cannot be achieved using a selected single film from Table 2-1:<br>▪ Separate radiographs may be produced to achieve the density requirements of section 2.3.2 for each wall thickness; or<br>▪ Cassettes should be double loaded using two suitable complementing speed films selected from Table 2-1 to achieve the required density range across the transition. |

**Notes:**

[1] A single-wall exposure, single wall view radiographic technique shall be used whenever practical. A double-wall, single image, technique shall have a minimum of three exposures for each weld.

### 2.4.2 Alternative Radiographic Technologies

The use of real time radiographic (RTR) imaging techniques or a digital image acquisition medium require pre-qualification by the Company. All relevant quality requirements detailed in the specification and applicable construction code will apply to these systems and imaging mediums. These Company pre-qualifications will be contractor specific and not global pre-qualifications based on equipment manufacturer.

### 2.4.3 Procedures

Radiographic examination shall be performed by the Contractor in accordance with a documented, detailed procedure provided by the Contractor and approved by the Company.

### 2.4.4 Quality Management

Prior to the start of the project, the Contractor shall submit to the Company, a project-specific Implementation Plan together with a Quality Management Plan, upon request.

#### 2.4.4.1 Audits

All NDE operations are subject to audit by the Company. NDE audits shall be planned and conducted by a Company auditor with appropriate qualifications in non-destructive examination, on a periodic but random basis, to verify compliance with Specification and Contract requirements. The Company auditor shall have the right to examine all procedures, reports, radiographs, and equipment both during and after production of radiographs, complete an audit report, recommend disposition of any nonconformance, and suggest appropriate corrective actions when required. If the Company audit finds a required corrective action, these findings shall be addressed in a timely manner.

The audit process is detailed in TEP-NDT-ADT Procedure for Nondestructive Examination (NDE) (EDMS No. 3797402).

Production Radiography

The following sections outline key requirements for radiographic examination of welds including visual examination, image requirement, information only exposure, interpretation, sensitivity, blemishes, inspections and repairs.

The radiographic procedure, technique, and test radiograph shall be on-site and available for review.

### 2.4.5 General

When the radiographic source is outside and more than 0.5 inches (12.7 mm) from the weld surface, at least four exposures separated by 90 degrees shall be made for the radiographic inspection of a complete weld.

Whenever more than one film is used to inspect a weld:

- Complete weld identification shall appear on each film segment;
- Adjacent films shall overlap by a minimum of 2 inches (50.8 mm);

- At the ends of adjacent films, the same circumferential location marker shall appear on both films, as evidence of complete coverage; and
- When more than one film cassette is used for a single exposure, the sealed end of the first cassette shall be in contact with the pipe surface and the flap end of the next cassette shall overlap the first. Subsequent cassettes shall follow the same configuration.

The radiation angle with respect to the weld and film shall be as near to perpendicular as possible with a maximum deviation of five degrees except when superimposed, double wall exposure, double wall viewing procedure is used.

### 2.4.6 Visual Inspection

Prior to radiographic examination, the Contractor shall visually examine each weld to ensure welds or piping with conditions such as arc strikes, or imperfections which exceed the requirements of Section 2 are repaired prior to performing radiographic examination.

### 2.4.7 Radiographic Image requirements

The Contractor shall ensure that the materials used to provide the radiographic images on the film meet the requirements of the Company, ASTM 1999, and API 1104. Details regarding the intensifying screen and film density requirements are outlined in Table 2-4.

**Table 2-4: Intensifying Screen, Film Density, and Film Development Requirements**

| Item | Details |
|---|---|
| Intensifying Screens | • Shall be made from lead.<br>• Front and back screens shall have a minimum thickness of 0.005 inches (0.13 mm).<br>• When performing gamma radiography, the recommended thickness for back screens is 0.010 inches (0.26 mm) to account for backscattered radiation.<br>• The back screen thickness shall be equal to, or greater than the front screen thickness.<br>• A center screen shall be used when double loading cassettes.<br>• The recommended thickness for center screens, when required for a multi film technique, is 0.010 inches (0.26 mm).<br>• Damaged screens shall be discarded.<br>• Fluorescent and Fluorometallic intensifying screens shall not be used.<br>• Prepackaged Radiographic film sandwiched between lead screens in a vacuum sealed, flexible cassette may be used with intensification screens thinner than specified above provided all quality requirements of this Specification and API 1104/ASME V, as applicable, are met. |

| Item | Details |
|---|---|
| Density Measure | • To ensure that film densities are within specified limits, a calibrated densitometer shall be provided for each construction spread and a certified density strip traceable to a national standard shall be provided for each darkroom provided by the Contractor.<br>• The densitometer shall have a valid calibration certificate.<br>• The film strip should have density steps ranging from 0.30 to 4.0 H&D.<br>• The use of a film strip alone to estimate radiograph or defect density is prohibited.<br>• Farmer's Reagent or similar solutions for density reductions shall not be permitted. |
| Film Processing | • Sight development techniques are prohibited.<br>• Time and temperature for development, stopping, rinsing, and fixing film shall be in accordance with ASTM 1999.<br>• Film shall be fully fixed.<br>• Time in the fixer shall be at least twice the clearing time, but not less than three minutes.<br>• Wash time for manual processing shall be at least twenty minutes, whenever practical.<br>• Wash water shall be changed as needed, but at least once per day.<br>• The Contractor shall provide thermometers and timers for all inspection units.<br>• Dates of solution changes shall be posted in the darkroom at all times and documented in a project log.<br>• All chemicals required for film processing shall be prepared and properly discarded in accordance with the manufacturer's directions.<br>• Disposal shall be in accordance with environmental regulations.<br>• All darkrooms used for film processing shall be equipped with forced air film dryers.<br>• Final interpretation of all film shall be performed on properly dried film. |

### 2.4.8 Information Only Exposures

The execution of "Information Only" exposures shall adhere to the requirements in this Specification and shall meet all Company and API 1104/ASME V, as applicable, quality requirements. Radiographs that do not meet all Company and API 1104/ASME V, as applicable, quality requirements shall not be subject to interpretation.

### 2.4.9 Interpretation

For final film interpretation, the Contractor shall provide a variable luminosity, high intensity viewer with a screen size of sufficient capacity to allow adequate viewing of film having a density up to H&D 4.0. The Contractor shall provide another identical high intensity, variable luminosity viewer and calibrated densitometer for use by the Company in the field office.

### 2.4.10 Radiographic Sensitivity

Radiographic sensitivity shall be measured using an image quality indicator (IQI). Wire type IQI's shall be used, conforming to ASTM E747 or ISO 19232-1. Hole type IQI's are prohibited. See Table 2-5 for required IQI essential wire image visibility per API 1104.

Unless notified in writing by the Company, API 1104 shall be the code of construction. The thickness of the weld shall mean nominal pipe wall thickness plus the average weld reinforcement (internal plus external combined). The value of the total thickness of reinforcement applied during IQI selection shall not exceed the lesser of 0.125 inches or the maximum allowed by the code of construction. The number of IQI's, and their placement, shall be per the code of construction. Film side IQI 's shall be identified using a lead letter "F".

The radiographic images of IQI identifying style number and ASTM set letter or ISO designation shall appear clearly across the entire area of interest. The IQI shall be placed across the weld and the long axis of the wires shall be perpendicular to the weld axis. The image of the essential wire diameter shall appear clearly across the entire area of interest. All wires shall completely cross the weld. Damaged wire sets shall be discarded. In cases where weld cap width exceeds the IQI length, IQI's shall be placed from both perpendicular directions.

For transition welds between two wall thicknesses, the thinner wall shall be used to determine the required sensitivity.

**Table 2-5: API 1104 Weld Thickness Versus Diameter of Wire Type IQI**

| Weld Thickness | Essential wire | ASTM E 747 Set | ISO 1027 Wire Identity |
|---|---|---|---|
| Less than 0.250" (6.4 mm) | 0.008" (0.20 mm) | A | 13 |
| 0.250"through 0.375" (6.4 to 9.6 mm) | 0.010" (0.25 mm) | A or B | 12 |
| Greater than 0.375" through 0.500" (9.6 to 12.7 mm) | 0.013" (0.33 mm) | B | 11 |
| Greater than 0.500" through 0.750" (12.7 to 19 mm) | 0.016" (0.41 mm) | B | 10 |
| Greater than 0.750" through 1.0" (19 to 25.4 mm) | 0.020" (0.51 mm) | B | 9 |
| Greater than 1.0" through 2.0" (25.4 mm to 50.8 mm) | 0.025" (0.64 mm) | B | 8 |

### 2.4.11 Blemishes

Radiographs presented for interpretation shall be free from blemishes or film defects that might mask or be confused with imperfections in the material. To ensure adequate control of back scatter, a lead letter "B" shall be attached to the back surface of the film cassette. If a light image of the "B," appears on a darker background of the radiograph, protection from backscatter is insufficient and the radiograph shall be considered unacceptable. A dark image of the "B" on a lighter background is not cause for rejection.

Typical blemishes include, but are not limited to one or more of the following:

- Fogging caused by light leaks or defective safelights
- Exposure marks caused by improper processing or old film
- Mechanical processing defects such as streaking, air bubbles watermarks, or chemical stains

- Blemishes caused by dirt in film holder
- Pressure or lead marks, scratches, gouges, finger marks, crimp marks or static electricity damage
- Loss of detail caused by poor film to screen contact in localized areas

Geometric unsharpness shall be kept to a minimum and shall not exceed 0.020 inches (0.5 mm) for weld thicknesses less than 2 inches (50.8 mm).

### 2.4.12 Delayed Inspection

When a delayed inspection is mandated by the Company, the weld shall be radiographed for initial acceptance for code compliance. The second (i.e. delay) inspection for final acceptance shall occur after the required delay time.

Defects found during the initial inspection shall be repaired. The delay time for final acceptance, if required, will commence once the repair has been completed.

The time of radiography will be marked on the pipe near the marked weld time. The time of radiographic examination shall be identified in the radiographic report.

### 2.4.13 Repair Welds

When a repaired weld is radiographed, an additional IQI shall be placed across to each repaired area.

## 2.5 Film Identification

The Contractor shall clearly identify each radiographic film with a unique weld identification number designated by the Company, along with any other information specified by the Company, in a manner approved by the Company (e.g., lead numbers and letters, or flash cards (EDMS No. 8737175). Table 2-6 details the required information.

**Table 2-6: Film Identification Requirements**

| Item | Details |
|---|---|
| Location Markers | • Location markers shall be provided so that discontinuities in the weld can be quickly and accurately located.<br>• The location markers shall be placed on the pipe on the downstream side of the weld, so that the numbers shall be read clockwise when viewed on the upstream side.<br>• Identification and location markers shall be readily visible on radiographs and shall not encroach on the weld image or other area of interest.<br>• Identifying numbers or letters shall be at least 3/32 inches (2.4 mm) high. |
| Marker Separation | • The maximum separation for weld location markers shall be 2 inches (50 mm) for NPS 16 and smaller welds, and 6 inches (150 mm) for welds larger than NPS 16. |
| Zero Location | • The zero location number shall correspond to the 12 o'clock position on the pipe whenever practicable. |

## 3 VARIANCES

Any deviation must follow the appropriate TransCanada Management of Change (MOC) Variance Procedure (EDMS No. 7728702).

## 4 ROLES AND RESPONSIBILITIES

Table 4-1 outlines the roles and responsibilities required for the use of this Specification.

**Table 4-1: Roles and Responsibilities**

| Role | Responsibilities |
|---|---|
| Radiographer | The radiographer shall be responsible for the protection and monitoring of every person working with or near radiation sources. The protection and monitoring shall comply with applicable federal, state, and local regulations. |
| Welding Inspector | The Welding Inspector is responsible for monitoring / confirming that:<br>• All welds are examined in accordance with this specification |
| Contractor | The Contractor is responsible for ensuring:<br>• All required welds are examined in accordance with this specification |
| Level I Radiographer | The Level I Radiographer is responsible for providing assistance where necessary to the Level II and Level III Radiographer(s) |
| Level II or III Radiographer | The Level II or III Radiographer is responsible for ensuring:<br>• That the final film is interpreted and reported<br>• Proper conduct and performance of all NDE Personnel<br>• Compliance with acceptance criteria |
| Technical Lead or Supervisor | The Technical Lead or Supervisor is responsible for ensuring:<br>• That the final film is interpreted and reported<br>• Proper conduct and performance of all non-destructive examination and personnel<br>• Compliance with acceptance criteria and specification including documented proof of review<br>• Maintenance of all Contractor facilities, equipment, and supplies in a reliable condition<br>• Preparation of accurate, consistent, legible and concise reports in a timely manner |

## 5 TRAINING AND QUALIFICATIONS

If required by the Company, the Contractor shall provide training (one-day minimum) for Company Inspectors on the Contractor techniques and management system for radiographic inspection. This training shall be at a date and location designated by the Company and shall occur prior to the start of production welding.

To ensure the consistent production of high quality radiographs, radiographic personnel shall be qualified in accordance with this section. A minimum qualification for personnel referred to herein as Level II radiographers shall be:

- Certified by examination in the radiographic test method in accordance with ASNT SNT-TC-1A, CP 189 or ACCP recommended practice;
- Qualified by production of at least one test radiograph for each Company approved radiographic technique used on the work (see Section 2.3.2) which shall be retained and evaluated by the Company on the basis of overall film quality and adherence to these specifications; and
- Approved by the Company for the work prior to production where practicable.

Personnel shall provide the following documentation:

- Background and experience record
- Company or ASNT/ACCP certification records
- Training course record
- Date of qualification and re-qualification
- Jaeger J-2 Acuity eye tests and results
- Operator Qualification (OQ) results for the radiographic method (conditionally required)

All Level II and III supervisory personnel should be qualified as a minimum to ANSI/ASNT-CP-189.

The Company shall have the right to evaluate the qualifications of all NDE personnel and to exclude individuals that, in the opinion of the Company, lack necessary training or experience for the work or have demonstrated an inability to adequately perform the prescribed examinations. Incompetence or lack of diligence at any time may result in immediate termination from the project.

## 6 SAFETY CONSIDERATIONS

The Contractor and all personnel operating X-ray or gamma-ray equipment shall be responsible for the protection and monitoring of every person working with or near radiation, and for compliance with the regulations of the Department of Health and Welfare Canada, Health Protection Branch concerning radiation safety, transportation, and certification.

The Contractor shall have a written radiation safety plan satisfying United States Nuclear Regulatory Commission (USNRC) requirements and applicable federal, state, and local laws, available on the work site at all times. This radiation safety plan shall be available for review upon request.

Personnel conducting radiographic operations shall properly utilize the following:

- Personal Thermo Luminescent Dosimeter (TLD) or film badge

- Survey meter with valid calibration
- Accumulative dose monitors (dosimeters) with valid calibration
- Rate alarm meter with valid calibration
- Appropriate type and number of radiation warning cones, barriers, signs and/or tape

## 7 ENVIRONMENTAL CONSIDERATIONS

No incremental Environmental Considerations are identified for this Specification.

## 8 GLOSSARY

Definitions related to this Specification can be found in Appendix A.

## 9 REFERENCES

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

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 9-1.

**Table 9-1: External and Internal References**

| Document No. | Title |
|---|---|
| **Legal Requirements** | |
| DOT 49 CFR 192 | Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards and any amendment, supplement or errata issued by the DOT. |
| DOT 49 CFR 195 | Transportation of Hazardous Liquids by Pipeline and any amendment, supplement, or errata issued by the DOT. |
| United States Nuclear Regulatory Commission (USNRC) | Federal Radiation Safety Regulations. State and local jurisdiction regulations also apply. |
| **Industry Codes and Standards** | |
| API 1104 | Welding of Pipelines and Related Facilities. |
| ASNT-CP-189 | American Society of Non-Destructive Testing (ASNT) Standard for Qualification and Certification of Nondestructive Testing Personnel. |
| ASNT-TC-1A | ASNT Recommended Practice for Qualification and Certification of Nondestructive Testing Personnel. |
| ASTM E94 | Standard Guide for Radiographic Examination. |
| ASTM E747 | Standard Practice for Design, Manufacture, and Material Grouping Classification |

| Document No. | Title |
|---|---|
| | of Wire Image Quality Indicators (IQI) Used for Radiology. |
| ASTM E999 | Standard Guide for Controlling the Quality of Industrial Radiographic Film Processing. |
| ASTM E1316 | Standard Guide for Terminology for Non Destructive Examinations |
| ASTM E1815 | Standard Test Method for Classification of Film Systems for Industrial Radiography. |
| ISO 19232-1 | Non-destructive testing - Image Quality of Radiographs - Part 1: Image Quality Indicators (Wire Type) - Determination of Image Quality Value |
| **Internal References – Documents that Reference this Specification** | |
| EDMS No. 1001828336 | TEN-NDT NDT Standard (CDN-US-mex) |
| EDMS No. 1001828218 | TES-WELD-API Welding of Pipelines and Facilities Specification (US-MEX) |
| **Internal References – Documents Referenced by this Specification** | |
| EDMS No. 3797402 | TEP-NDT-ADT Procedure for NDE Audits Specification (US-MEX) |
| EDMS No. 1001828218 | TES-WELD-API Welding of Pipelines and Facilities Specification (US-MEX) |

## 10 DOCUMENTATION AND RECORDKEEPING

Due to the broad range of data types that may be required in support of this Specification, there are a number of processes that may need to be utilized for documentation purposes. These data types include but are not limited to:

- storage of developed radiographic images/film
- daily radiographic reports
- project log
- Radiographic Examination Procedure Qualification Form “F” (EDMS No. 8732529)
- radiation safety plan
- weld repair list

### 10.1 Storage of Developed Radiographic Images/Film

All radiographic films and associated documentation shall become the property of the Company. Unless authorized by the Company in writing, duplicate production radiographs shall not be executed. Electronic transfer of production radiographs is subject to written Company approval.

#### 10.1.1 Processing for Storage

All radiographic films shall be processed by the Contractor prior to being stored in a location determined by the Company. Table 10-1 details the requirements of this processing.

**Table 10-1: Processing Film for Storage**

| Item | Details |
|---|---|
| Wash Film | • The Contractor shall ensure that all film is thoroughly washed and dried before packaging and that all film is packaged in sequential order with a copy of the Daily Radiographic Report. |
| Catalogue Film | • Completed radiographs shall be either catalogued and packaged in cardboard boxes supplied by the Contractor, or for fabrication welds or oversize films, in suitable sized envelopes.<br>• The contents shall be clearly identified on each envelope. These envelopes will then be stored in suitable sized boxes and identified using a label for archiving.<br>• For cubicle boxes, radiographs shall be inserted into each cubicle in sequence stating from the left side of the first row toward the right and then from the right side of the second row toward the left and so on. The bottom of each cubicle shall be clearly marked with the film number, i.e. weld number that shall occupy that space, after the radiograph has been interpreted. |
| Processing of Radiographs of Repaired Welds | • Radiographs of repaired welds shall be rolled or inserted with the original radiograph such that both films are stored in the same cubicle or when envelopes are used they shall be included in the same envelope/box. |
| Processing of Radiographs of Replaced Cut-out | • Radiographs of replaced cut-out welds shall be placed in the same cubicle or envelope as the original film. If there is not enough room, then the original film may be removed and filed in a box/envelope identified as a cut-out box. |
| Removal of Staples | • All staples used to hold film(s) together shall be removed prior to storing. |
| Interpretation Sheets | • Clear and legible interpretation sheets shall be included inside the boxes for those films catalogued in the corresponding boxes. Each time a new box is started, a new interpretation sheet shall be started. These sheets shall then be inserted inside the corresponding box or envelope. |
| Labeling | • The Contractor shall supply labels for the radiographic boxes. The boxes and labels shall be numbered sequentially starting from number one. As films are being processed, the Contractor shall complete the labels with the information specified below and place the labels in the same location on the side of each completed radiographic box.<br>▪ Project name, location, or spread number<br>▪ Range of weld numbers<br>▪ Range of chainage, for pipeline projects when requested by the Company<br>▪ Range of dates exposed<br>▪ Box number<br>▪ Contractor's name<br>▪ Other specific information required by the Project/Construction Manager |

| Item | Details |
|---|---|
| Storage | • Radiographic film and associated reports shall be forwarded to the Company for storage. Film processing shall be adequate to permit storage without deterioration for a minimum period of seven years. |

### 10.2 Project Log

The Contractor or Fabricator shall keep a logbook approved by the Company for repairs of all welds throughout the project. At the completion of the project, the Contractor shall provide a copy of the approved logbook to the Company.

### 10.3 Daily Radiographic Reports

At the end of each day, the Contractor shall supply to the Company details of all radiographic inspection completed that day on the Daily Radiographic Reports.

Radiographic inspection reports shall include but are not limited to the following information:

- Date of inspection (i.e. Month/Day/Year)
- Film type used
- Technique used
- Source strength (curies or Ma/Kv)
- Pipe diameter and wall thickness
- IQI identification
- Company, project name and number
- Code of construction as per construction requirements
- Company Specification and acceptance criteria used
- Spool number (if applicable)
- Weld number
- Disposition
- Technician name and certification
- Company representative approval
- Density measure taken of daily unexposed base film

#### 10.3.1 Weld Repair List

Weld repair lists shall be provided to the Company in electronic and hard copy format each working day at a cut off time specified by the Company and agreed to by the Contractor.

Repair lists shall report weld quality, including outstanding weld repairs and/or cutouts, for all welds completed prior to the production cut off time on that day.

The Contractor shall have sufficient equipment and personnel on site to maintain a production rate, which ensures any weld completed prior to the production cut off time on any working day shall be inspected, interpreted, and included in the Daily Radiographic Report for that working day.

## 11 DOCUMENT HISTORY

| Rev. | | |
|---|---|---|
| 05 | **Description** | **Effective Date** |
| | Revised document developed as part of Engineering Standards Streamlining Process. | 2016-Nov-01 |
| | **Rationale Statement** | **Responsible Engineer** |
| | This document was revised in order to address the following requirements:<br>Alignment with new document definitions, structure, and templates. | Simon Hsu,<br>Sr. Welding Engineer |
| | **Impact Assessment Summary** | **Document Owner** |
| | This specification was revised to streamline the documentation required for the NDE group and to make it more easily accessible to those who use it. | Simon Hsu,<br>Sr. Welding Engineer |

## 12 DESCRIPTION OF CHANGE

| Section | Description of Change |
|---|---|
| **Regulatory** | |
| N/A | N/A. |
| **Industry Standards** | |
| N/A | N/A. |
| **General** | |
| N/A | This Specification is a new document. |

## 13 APPROVALS

| APPROVALS | | |
|---|---|---|
| Originator:<br>Salvatore Delisi, Senior Welding Technologist<br>Welding and Materials Engineering | Salvatore J. Delisi<br>Signature | 10/25/16<br>Date |
| Reviewer:<br>Jason Althouse, Senior NDE Technologist<br>Welding and Materials Engineering | Signature | 10/25/16<br>Date |
| Responsible Engineer:<br>Simon Hsu<br>Sr. Welding Engineer<br>Welding and Materials Engineering | Simon Hsu<br>Signature<br>10/25/2016<br>Date | |
| Management Endorsement:<br>James Ferguson, Manager<br>Welding and Materials Engineering | Signature | Nov. 1, 2016<br>Date |

## APPENDIX A TERMS AND DEFINITIONS

| Terms | Definitions |
|---|---|
| **Assembly Weld** | Weld joining pipe to components, or components to components; weld joining pipe to pipe made in stations or at a manufacturing plant or fabrication shop remote from the final location of the weld |
| **Company** | TransCanada including their engineering agencies, inspectors and other authorized representatives. |
| **Component** | Valves, fittings |
| **Contractor** | The Contractor engaged by the Pipeline Construction Contractor to perform the radiographic inspection work covered by this Specification. |
| **DWDI** | Double-wall, double-image |
| **DWSI** | Double wall, single image |
| **IQI** | Image quality indicator |
| **Mainline Weld** | Pipe-to-pipe weld made on a pipeline site |
| **Radiographic Personnel** | Operators of radiographic equipment. Radiographers referred to herein shall be certified to Level II or III in accordance with a written practice based on the latest edition of ASNT SNT-TC-1A or ANSI/ASNT-CP-189. Level I personnel (trainees) are not considered to be radiographers. |
| **Pipeline** | A pipeline for the transmission of natural gas or hazardous liquids including laterals, branch connections, extensions, compressors, pumps, and related facilities as defined by 49 CFR 195 Transportation of Hazardous Liquids by Pipeline or by 49 CFR 192 Transportation of Natural and Other Gas by Pipeline, Minimum Federal Safety Standards. |
| **Nondestructive (NDE) Audit** | An official examination of the Contractor's procedures, reports, radiographs, equipment and systems used for nondestructive examinations. |
| **SWSI** | Single-wall, single-image |

## PURPOSE

This Specification is issued to provide the Company requirements for ultrasonic examination of girth welds.

## SCOPE / APPLICABILITY

This Specification details the requirements for the examination of pipeline girth welds using a mechanized and manual (APPENDIX C) ultrasonic examination system. The requirements outlined include: contractor requirements; equipment; calibration standards, procedures, techniques, and quality management; system set-up; examination; indicator evaluation; and records and reports.

This Specification applies to new welds made in pipe with a nominal wall thickness of:

- 0.250 in. (6.4 mm) and greater with a factory weld bevel
- 0.283 in. (7.2 mm) and greater with a gas metal arc weld bevel

This Specification applies to the Company and its wholly-owned subsidiaries, and all operated entities/facilities in the United States (U.S.) and Mexico.

The Responsible Engineer shall be contacted for clarification if needed.

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# 1 CONTENT FRAMEWORK

The content framework in Figure 1-1 provides the general structure for the material as applicable to this Specification. This framework represents the requirement categories outlined in Section 2.

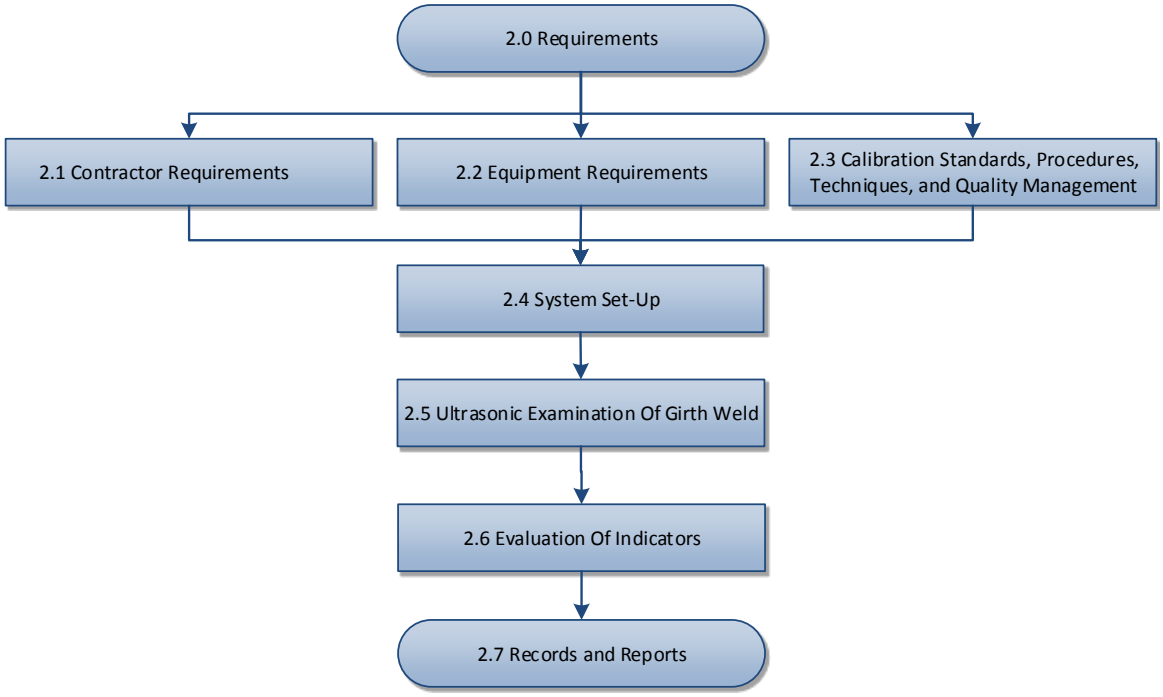



**Figure 1-1: Content Framework**

## 2 REQUIREMENTS

All ultrasonic examination of girth welds shall conform to the following requirements:

- Notwithstanding the requirements set forth herein, ultrasonic examination shall comply with the requirements of the latest approved edition of API 1104, as incorporated by reference by 49CFR 192.7, or 49CFR Part 195.3, as appropriate.
- While most project work will be performed to API 1104 standards, in some cases, ultrasonic procedures may be developed in accordance with ASME V, and evaluated to ASME Section VIII, Division I, Mandatory Appendix 12. While this Specification defaults to API 1104, the NDE Contractor will be so advised when ASME criteria is relevant. For purposes of this Specification, references to API 1104 also include ASME criteria, if relevant.
- Mechanized girth welds, girth welds made in a factory bevel, and repairs made to welds produced using mechanized welding shall be fully examined by an automated ultrasonic examination system for 100% of the circumference, in accordance with API 1104, Appendix A.
- Girth welds made in a factory bevel which cannot be inspected by automated ultrasonic examination may, where practicable and with permission of the Company, be inspected by manual ultrasonic examination according to APPENDIX C of this Specification.
- The examination system shall be capable of assessing circumferential length of defects and predicting the through-wall height and circumferential length of defects, in a manner that permits the use of acceptance criteria defined by the Company in accordance with API 1104, Section 9.6.2 “Acceptance Standards”.
- Each examination system shall incorporate a time of flight diffraction (TOFD) configuration; this shall augment, but not replace, the pulse-echo system.
- The Pipeline Contractor should be aware of these requirements and work with the NDE Contractor to ensure that welds are prepared and available for examination as required by the Company.
- The Company shall have the right to non-destructively examine any weld; the examination shall be used to assess compliance with CFR 192, 49 CFR 195, and API 1104. The Company shall also have the right to require the removal of any weld for the purpose of destructive tests.
- The Company is the final authority for the acceptance of welds.
- For each project, the Contractor shall demonstrate the accuracy of the system for assessing through-wall height imperfections according to API 1104 Appendix A in welds produced in project pipe. The accuracy should be verified by destructive testing results unless an alternate approach is applied, in accordance with API 1104 Appendix A. This accuracy shall be demonstrated on the thinnest and the thickest wall thickness of project pipe. The Company shall be sole judge of the adequacy of system performance for the intended use.

## 2.1 Contractor Requirements

The Contractor shall provide ultrasonic examination services for all automatic girth and any other welds designated by the Company during the construction of a pipeline or facility, as described in Section 2.5 of this Specification.

Before system mobilization, all the performance tests and documents listed in Section 10 shall be completed by the Contractor and approved by the Company.

The Contractor shall have sufficient equipment and personnel on site to maintain a production rate which ensures that any weld completed prior to the daily cut off time specified by the Company shall be inspected, interpreted and included in the Ultrasonic Examination Report for that working day, unless otherwise directed by the Company.

Table 2-1 outlines other key requirements of the Contractor.

**Table 2-1: Contractor Requirements**

| Topic | Description |
|---|---|
| Designs | • Project specific examination designs shall be developed by the Contractor following the requirements of APPENDIX A of this Specification for mechanized welding bevel configurations, and APPENDIX B for welds produced in a standard factory bevel.<br>• Using either the design information provided by the Company or derived from the relevant Appendix, the Contractor shall prepare a detailed technique for each wall thickness to be inspected by automated ultrasonic examination.<br>• The Contractor shall only prepare a detailed technique(s) for manual ultrasonic examination when required by the Company. |
| Equipment | • The Contractor shall have necessary spare equipment to ensure continuance of the work without interruption or delays.<br>• The Contractor shall supply a viewer program to enable the Company to view the raw data in the same manner used by the system operator at the time of examination.<br>• The program shall allow the Company to verify amplitude or TOFD indication height values from the raw data, in addition to viewing the specific scan parameters used, including focal law information for phased array systems. |
| Personnel | • The Contractor shall designate one person as the NDE Supervisor. This person shall be responsible for the conduct and performance of all ultrasonic personnel and for maintaining all equipment and supplies in reliable condition.<br>• The NDE Supervisor shall be a certified Level II or Level III (ASNT TC-1A, ACCP, CP-189) in the ultrasonic method and work closely with the Company's Senior Welding Inspector in the documentation of examinations completed and shall be responsible for all reports, interpretations, and evaluation.<br>• The NDE Supervisor shall audit daily the electronic data to ensure that interpretations are consistent, informative, and concise, and the NDE Supervisor shall be capable of technical support for NDE operations. The extent of data audit shall be approved by the Company.<br>• The NDE Supervisor shall be approved by the Company based upon experience, technical knowledge, and NDE qualifications for the duties to be performed. |

| Topic | Description |
|---|---|
| Records | • The Contractor shall provide the Company with an electronic copy of the raw data and a hard copy or PDF recording of the examination, together with the judgment of acceptability of each weld examined and the recordings of the calibration standard scans.<br>• The raw data shall capture the A-scan signal within the gated period of each sequence at a sampling rate allowing proper reconstruction of the signal. |

## 2.2 Equipment Requirements

The ultrasonic examination shall be carried out using an automatic ultrasonic system capable of maintaining production rates established by the Pipeline Construction Contractor. At times, this can be as many as 150 welds/day. The system shall be self-contained, have its own independent power supply, and be mounted on a suitable all-terrain vehicle.

A stacked A-scan mapping display shall be provided for each root and volumetric sequence/channel in addition to an analog strip recording for all sequences/channels. A selectable A-scan presentation shall be available during scanning.

When required, there shall be an A-scan presentation of the gated period available for viewing in the display for any selected analog strip sequence/channel during scanning. The instrument shall provide a linear A-scan presentation for each channel selected. The examination channels shall allow assessment of the full volume of the weld scanned, and all defects present detected, located, and sized in the circumferential and through-wall direction. Instrument linearity shall be determined according to ASTM E317, within 3 months of the intended end use date, and not deviate by more than 5% from ideal. The Contractor shall retain a current copy of the calibration certificate at the worksite.

Each examination channel shall provide:

- Pulse echo or through transmission modes
- Two gates, each adjustable for start position and length
- Gain adjustment independent of the other examination channels
- Recording threshold between 5% and 100% of full screen height (FSH) for A-scan and transit time recording and 0% to 100% for stacked A-scan mapping
- For TOFD waveforms, a recording threshold of 100% to -100%
- Recording of the first or the largest signal in the gated region
- Signal outputs representing signal amplitude and time of flight

Table 2-2 outlines additional requirements for Phased Array, Time of Flight Diffraction, and Transducers.

**Table 2-2: Additional Equipment Requirements**

| Equipment | Description of Requirement |
|---|---|
| Phased Array (PA) | Phased array technology may be used as an alternative to a focused multi-probe array. In that circumstance, the Contractor shall apply the following additional requirements:<br>• Phased array systems will simulate the focused multi-probe array system function for weld volume examination. Sectorial scans are permissible when required to provide enhanced defect height sizing.<br>• Phased array equipment shall meet the requirements of Part 1, 2, and 3 of BS EN 12668.<br>• Phased array transducers shall have a minimum of 48 elements. Due to the large wedge footprint (and therefore sensitivity to surface waviness), care must be taken to ensure the contact surface is properly dressed to match the contour of the pipe surface. The permissible gap between pipe and wedge shall not exceed 0.010 in. (0.25 mm).<br>• Phased array transducers shall contain shaped elements or suitable lens in the passive non-steered direction, radius three (3) to five (5) inches (75 to 125 mm). Alternatively, phased array transducers that result in a beamspread limitation of 4 mm in the passive non-steered direction may be permissible.<br>• Each array will be assessed at intervals not exceeding 800 welds or 1 week of production, whichever comes first, to confirm continued element integrity and performance within the Manufacturer's acceptable tolerance. The Contractor shall follow the Manufacturer's performance tolerances with respect to sensitivity across the array and the number of non-active elements.<br>• Each focal law will provide for the maximum sound pressure at the target defined in the examination design. The focus shall occur at the target ±10 mm of steel path and the beam height shall be within ± 20% of that required by the examination design.<br>• Software locks should be active for each focal law to limit changes by the system operator which will alter the initial system configuration approved by the Company Representative. Changes shall only be permitted by the Contractor Job Supervisor with approval of the Company Representative. The Contractor shall demonstrate the tolerance to ideal for each focal law.<br>• With permission from the Company, a software feature which identifies that a focal law is outside the tolerance set for that focal law may be substituted for software locks. This out of range condition shall appear in the display continuously until corrected and recorded in the raw data for welds examined with this out of range condition. |
| Time of Flight Diffraction (TOFD) | • A single TOFD configuration shall be used for wall thickness ≤ 1 in. (25 mm), whereas a dual TOFD configuration shall be used for wall thickness > 1 in. (25 mm).<br>• TOFD shall be configured following BS EN 583-6:2008 guidelines.<br>• The receiver bandwidth shall have a range of 0.5 to 2 times the nominal transducer frequency at -6dB.<br>• The system shall have an electronic gate with both start and length within the unrectified A scan which is digitized.<br>• Lateral Wave (LW) shall be a minimum of 12 dB greater than baseline noise.<br>• The gate should be set starting 1 microsecond prior to the arrival of the lateral wave and extend to ensure that both the complete reflected back wall signal and the mode converted signal is recorded. |

| Equipment | Description of Requirement |
|---|---|
| | • The digitization rate shall be at least 4 times the nominal transducer frequency.<br>• The system shall be able to acquire, digitize, and display at least one A-scan for each 1mm of scan length.<br>• The system shall be capable of displaying D-Scan images in at least 256 grey scale levels.<br>• If pre amplifiers are used, then the bandwidth of the pre amplifier at -3dB shall be similar to that of the system.<br>• The preamplifier shall be low noise, better than 20µV peak to peak. |
| Transducers | • All transducers shall utilize contoured wedges to match the curvature of the pipe surface.<br>• Transducers shall not operate on or transmit/receive ultrasonic energy through the coating.<br>• The acoustic focus shall occur at the target ±10 mm of steel path and the beam height shall be within ±25% of that required by the examination design. The -6 dB horizontal dimension of the beam at the target shall not be greater than two times the -6 dB vertical dimension of the beam.<br>• Transducers other than phased array shall be certified as meeting the performance requirements of British Electrical Supply Industry Standard ESI 98-2.<br>• Each transducer's performance shall be documented before use on a Contractor developed form approved by the Company.<br>• Whenever wear is apparent, but not greater than an interval of 500 welds, transducers shall be examined for wear as per Section 2.4.3 of this Specification.<br>• The signal-to-noise value for each transducer shall be compared to the value obtained in accordance with Section 2.4.2 of this Specification at the start of the project.<br>• Case heights and the signal-to-noise value for each transducer shall be recorded on Company-approved forms.<br>• For conventional (non-phased array) transducers, the contact face shall be re-surfaced, or the transducers replaced to correct any of the following:<br>▪ Beam angle changes of ±1.5 degrees for angles less than 45 degrees, or ±2 degrees for angles greater than 45 degrees<br>▪ Squint angles exceeding 1.5 degrees for single crystal transducers and 2 degrees for twin crystal transducers<br>▪ A signal-to-noise value 6 dB less than the value obtained at the start of the project<br>▪ Scores in the transducer wear face which exceed 0.2 mm in depth<br>• Phased array transducers shall be replaced or resurfaced if the naturally refracted angle deviates more than ±1.5° of approved technique angle.<br>• Phased array transducers shall be re-surfaced if scores on the contact face exceed 0.2 mm in depth |

## 2.3 Calibration Standards, Procedures, Techniques, and Quality Management

This section describes the equipment calibration standards, procedures, techniques, and quality management requirements for automated ultrasonic examination of girth welds.

### 2.3.1 Calibration Standards

Calibration standards shall be used to qualify the system for field examination and to monitor ongoing system performance.

The following calibration standard requirements apply to automated ultrasonic examination of girth welds:

- Calibration standards shall be manufactured from a section of project specific line pipe supplied by the Company and designed such that the target reflectors simulate the bevel geometry to be inspected.
- Calibration standards shall be identified with a unique serial number providing traceability back to the project for which they were manufactured. Records of the serial number, wall thickness, diameter, and acoustic velocity shall be kept. Calibration standards remain the property of the Company.
- Calibration standards shall be designed with sufficient surface area so that the complete transducer array will traverse the target areas in a single pass. The lateral position of calibration reflectors shall be such that there will be no interference from adjacent reflectors, or the edges of the block.
- The number of calibration reflectors shall be adequate to provide better than ±1.5 mm of height sizing accuracy, clearly discriminate buried from surface breaking imperfections, as well as enable classification of imperfection type, planar, and volumetric as per API 1104, Appendix A.
- The calibration block shall contain a vertical slot or through-hole at each end. The purpose is to verify during the calibration scan that the gate has extended past the center line. The reflecting face of this reflector shall be coincident with the centerline of the calibration block.
- The acoustic velocity of each pipe material shall be determined in the same plane as the pipe axis using SH (Horizontally Polarized) shear waves polarized to simulate particle displacement during actual examination conditions. Measurements shall be made using parallelograms machined to represent the lowest and highest examination angles. Two complete sets of parallelograms shall be taken from each pipe section sets shall be separated by 180°. This data shall be considered during transducer design and be recorded in procedure logical report format and submitted to the Company for determination of calibration block quantities and dissimilar material velocity examinations (i.e., transition welds).
- Calibration standards shall be certified by the machine shop and a report shall be provided to the Company verifying the tolerance to design actual for each of the calibration reflectors. In addition, the Contractor shall ultrasonically verify the signal response from like kind reflectors on upstream versus downstream sides; a report demonstrating compliance to the above shall be provided to the Company.

Table 2-3 outlines the flat bottom holes (FBH) and deep surface notches measurements for the principal calibration reflector for fusion defects according to design type.

**Table 2-3: Principal Calibration Reflector for Fusion Defect and Porosity Detection Requirements**

| Design Type | Wall Thickness | Principal Calibration Reflector for Fusion Defects | Porosity Detection |
|---|---|---|---|
| Stressed-Based Pipeline Design | ≤ 1 in. (25 mm) | • 2 mm diameter FBH<br>• 1 mm deep surface notches<br>• 2 mm deep x 10 mm wide transverse notches<br>• 3 mm deep TOFD outside diameter (OD) notches<br>• 2 mm deep TOFD inside diameter (ID) notches | 1.5 mm |
| | > 1 in. (25 mm) | • 3 mm diameter FBH<br>• 1 mm deep surface notches<br>• 2 mm deep x 10 mm wide transverse notches<br>• 3 mm deep TOFD OD notches<br>• 2 mm deep TOFD ID notches | 2 mm |
| Strain-Based Pipeline Design | All | • 2 mm diameter flat bottom holes (FBH)<br>• 1 mm deep surface notches<br>• 2 mm deep x 10 mm wide transverse notches<br>• 3 mm deep TOFD OD notches<br>• 2 mm deep TOFD ID notches | 1.5 mm |

The central axis of each FBH calibration reflector shall coincide with the central axis of the sound beam interrogating it.

Machining tolerances for all calibration reflectors shall be less than or equal to the following:

- Hole diameter ± 0.1 mm
- Flatness of FBH ± 0.2 mm
- Angles ± 1 degree
- Notch Depth ± 0. 2 mm
- Notch Length ± 10%
- Center location ± 0.2 mm
- Hole depth ± 0.2 mm

### 2.3.2 Procedures

Ultrasonic examination shall be performed in accordance with a documented, detailed procedure technique approved by the Company. The Contractor shall provide an automatic ultrasonic examination procedure technique that meet the requirements of ASTM 1961, Section 6.7.

Approved procedures shall contain, as a minimum:

- the applicable information stated in this Specification
- information stated in ASME Section V, Article 4
- a description of the methodology used to investigate indications

The Contractor shall demonstrate the effectiveness of all proposed procedures and techniques to the Company prior to mobilizing each system to the project. The specific technique for each wall thickness will be assessed according to the performance requirements contained in Section 2.4 of this Specification. All project procedures/techniques must be approved prior to mobilization to the project. The Contractor shall not use any procedure or technique in the performance of the work that has not been approved by the Company. The Company shall be sole judge of the adequacy of the technique for the intended use.

Qualifying examinations shall be produced under site conditions and in the presence of the Company for each proposed procedure and/or technique. Such procedure acceptance testing shall be performed using Contractor weld procedure or welder qualification test welds. The qualification process shall be in accordance with API 1104 Section 11.4.4 and occur prior to the commencement of production welding.

The Company will notify the Contractor of its approval of each procedure and/or technique. Upon approval from the Company, the procedure becomes a mandatory requirement and changes are only permitted upon subsequent approval from the Company.

### 2.3.3 Techniques

Automated techniques, using either focused transducers or phased-array transducers, in combination with a minimum of A-scan, stacked A-scan presentations, and a fully automatic recording system, shall indicate accurately the circumferential location, length, and through-thickness location of indications as well as the continuity of acoustic coupling. The system analysis software shall be capable of determining the through-thickness height of indications with an accuracy ≤ 1.5 mm. System resolution shall be 1 mm of circumferential distance, and the system shall provide for encoder accuracy verification. Circumferential distance markers shall be provided at intervals not exceeding 1 cm of weld length.

### 2.3.4 Quality Management

The Contractor will submit a project-specific Implementation Plan together with a Quality Management Plan.

## 2.4 System Set-Up

Prior to commencing the ultrasonic examination, the system shall be optimized for field examination using the calibration standard established in Section 2.3 of this Specification.

### 2.4.1 Calibration Standard Scan

The calibration standard shall be used daily before beginning pipe weld examinations, after repairs to the system, and thereafter at intervals not exceeding 1 hour (or 10 welds, whichever comes first), and at the conclusion of the shift.

When changes are made to the setup (e.g., a change of wall thickness, transducer or wedge), then six acceptable consistency calibration scans are required.

The record copy of the calibration standard scan shall be included sequentially with the weld examination charts. The last weld number inspected and time at which it was performed should appear on each calibration chart. These charts shall be made available to the Company upon request.

### 2.4.2 Transducer Positioning and Primary Reference Sensitivity

Table 2-4 outlines the requirements for transducer positioning and primary reference sensitivity.

**Table 2-4: Requirements for Transducer Positioning and Primary Reference Sensitivity**

| Topic | Description |
|---|---|
| Primary Reference Level | • The system shall be optimized for field examination using the calibration standard established in Section 2.3.1 of this Specification.<br>• Each transducer shall be positioned at its operating distance away from the simulated weld centerline on the calibrated standard and adjusted to provide a peak signal from its target reference reflector in its examination zone.<br>• The peak signal response shall be adjusted to approximately 80% of the full screen height for each channel. This gain level shall be the primary reference for that transducer and shall be recorded in the procedure (see Section 2.3.2 this Specification).<br>• Variation and corrective actions to maintain calibration shall be recorded on a Company pre-approved form.<br>• The noise shall be at least 20 dB weaker than the signal at the target path, and the electronic noise 40 dB weaker.<br>• For the examination of welds when an alternate flaw acceptance criteria (ECA) is used, the signal discrimination between adjacent zones shall be a minimum 6 dB but not exceed 12 dB.<br>• For the examination of all welds when a workmanship flaw acceptance criteria is used, the signal discrimination between adjacent weld body zones shall, where practicable, be a minimum 6 dB but never exceed 12 dB. For those zones examining the pipe surfaces a minimum of 6 dB discrimination is required. |
| Gate Settings | • Using the calibrated standard, each detection gate shall be set to cover a sound path which starts at least 5 mm before bevel configuration, and ends at least 1 mm past the weld centerline.<br>• The gate start position and gate length with respect to the weld preparation for each detection channel shall be recorded in the procedure.<br>• For mapping (stacked A-scan), the gate shall mimic the start positions above and extend past the weld geometry where practicable. |

| Topic | Description |
|---|---|
| Gate Recording Threshold | • The recording threshold of each planar detection channel shall be 40% of full screen height when on the peak signal response from the target FBH or surface notch.<br>• The recording threshold of each porosity detection channel shall be 10% of full screen height when the 1.5 mm diameter FBH. |
| Data Display | • Channel output signals shall be arranged in the data display and PDF copy record in an order acceptable to the Company.<br>• Time delays shall be applied to the signals to compensate for different transducers circumferential positions relative to the circumferential zero point and subsequent distance markers.<br>• Details of the delays applied and the chart arrangement shall be recorded in the procedure.<br>• Variations and corrective actions to maintain calibration shall be recorded on a Company pre-approved form |
| Circumferential Scanning Velocity | • Scanning velocity shall not exceed values determined by the following calculation:<br>$V_c \leq W_c * PRF / 3$<br>▪ $V_c$ is the scanning velocity<br>▪ $W_c$, is the narrowest -6dB beam width at the appropriate operating distance(s) of all transducers in accordance with the design requirements<br>▪ PRF is the pulse repetition frequency per transducer |
| Circumferential Scanning Direction | • The circumferential scanning direction should be marked on the pipe with sufficient extent as to not be covered by coating application. |
| Operating Log | • A log shall be kept of adjustments, changes to measurements, dB changes or other changes from those stated in the original technique.<br>• Replacements will be documented (e.g., major system components, transducer wedge change-outs, transducer change-outs).<br>• Transducer details shall include angle, frequency, serial number, diameter, and focal position if focused. |

### 2.4.3 Calibration Qualification

Table 2-5 outlines the requirements for calibration.

**Table 2-5: Calibration Requirements**

| Topic | Description |
|---|---|
| Detection Channels | • With the system optimized, the calibration standard shall be scanned in the multiplexed mode.<br>• The recording medium shall indicate 70-100% (within specified tolerance) of full screen height signals from each calibration reflector recorded in their correct position assigned on the recorder chart.<br>• The circumferential positional accuracy of the recorded reflectors relative to each other shall be within ± 2 mm. |

| Topic | Description |
|---|---|
| | • A calibration acceptable to the Company shall be used as the examination quality standard to which subsequently produced calibration charts shall be judged for acceptability.<br>• Calibrations shall be performed at the same scanning speed as the weld examination – no stop/starting or rocking will be allowed, as this is intended to be a representative dynamic scan. |
| Coupling Monitor Channels | • Amplifier gain shall be adjusted when the system is mounted on the standard production weld to produce a maximum echo height of 80% from the full "vee" path, when using separate coupling monitors, or 80% full screen height and up to a maximum of +8 dB transmitted signal when in through-transmission mode.<br>• The recording gate threshold level shall be a minimum of 20% of full screen height to a maximum 80% of full screen height.<br>• For PA configurations, a methodology shall be established to confirm transducer coupling of all the elements in each array.<br>• The defined methodology must include at least two additional through-transmission coupling sequences one transmitted from upstream to downstream and one transmitted from downstream to upstream.<br>• The re-examination of the calibration standard with its surface wiped dry shall produce a record showing a lack of coupling (i.e., absence of recording signal). This shall be performed at least once per day. |
| Measurement to Assess Transducer Wear | • The Contractor shall provide baseline height measurement for the transducer case prior to the start of field weld examinations.<br>• An accurate (± 0.1 mm) measurement shall be made of the case height at each of the corners of each transducer. These measurements shall be recorded on a Company approved form for a comparison of periodic measurements taken throughout the project to assess transducer wear.<br>• The frequency of checks shall be defined in the procedure.<br>• An ongoing transducer performance monitoring process may be used as a substitute for physical measurements, if approved by the Company. |

## 2.5 Ultrasonic Testing of Girth Welds

The following sections outline key requirements for ultrasonic examination of girth welds including visual examination, weld marking, surface conditions, reference line, monitoring system performance, and re-testing.

### 2.5.1 Visual Examination

At the option of the Company, the Contractor or designate should confirm by visual examination, at suitable intervals and with a slip gauge, that the pipe bevel dimensions and alignment prior to welding conform to the dimensional tolerances of the ultrasonic testing procedure. Any differences in dimensions or alignment observed during setup and scanning should be reported to the appropriate Company representative.

### 2.5.2 Weld Marking

The Contractor shall permanently identify each weld with a unique weld number following the weld number system provided by the Company. The weld number shall be positioned on the pipe surface on the work side of the pipe in a manner agreed by the Company. Weld numbers shall be large enough to be clearly visually identified from a distance of 10 feet.

### 2.5.3 Surface Conditions

The scanning surface shall be free of weld spatter and other irregularities that may interfere with the movement of the transducers, the coupling, or the transmission of acoustic energy into the material.

Additionally, pipe coating shall be cutback for a minimum distance of 5 in. (125 mm) from the original bevel face. Spiral or long weld seams shall be ground within 0.5/-0 mm of the pipe surface for a distance measured along the length of the pipe of 5 in. (125 mm) from the original bevel face. This is to ensure that no transducers are lifted from the pipe surface during the scanning operation.

### 2.5.4 Reference Line

Prior to welding, the Contractor shall scribe a reference line on the pipe surface at a standardized distance from the weld centerline with an accuracy of ± 0.5 mm from the centerline of the weld preparation and on the examination band side.

The reference line shall be used to ensure that the band is adjusted to the same distance from the centerline to replicate the calibration standard. The tolerance to ideal positioning shall not exceed ± 0.5 mm. The 12 o'clock position shall also be clearly marked on the pipe to indicate the start position (0 in./cm) position of the scan.

The Contractor shall take into account the circumferential shrinkage of the girth weld during the design and calibration sequences. Shrinkage is determined by scribing a reference line on both pipe ends for the first 10 welds, then measuring the distance in between them after welding.

### 2.5.5 System Monitoring

Table 2-6 outlines the requirements for monitoring system performance.

**Table 2-6: Verifying System Performance Requirements**

| Topic | Description |
|---|---|
| Scanning Sensitivity | • An additional 4 dB of gain should be added globally to the system for weld examination to compensate for differences in coupling efficiencies between the calibration standard and the production pipe. This additional gain shall be removed during calibration. If additional 4dB is not added, a transfer correction shall be used.<br>• During production weld examination, with the Company's approval, the system may be operated at a higher gain to ensure detection of defects, or to account for excessive pipe surface roughness.<br>• This additional scan gain shall only be applied to planar detection sequences. The porosity detection sequences and TOFD sequence shall not have additional gain added These sequences already account for coupling differences due to their higher gain and lower recording threshold requirements. |
| Circumferential Position Accuracy | • The position accuracy of the chart distance markers shall be validated twice during each working shift.<br>• The scanner shall travel from the zero position with the scanning frame coincident with the pipe.<br>• At all o'clock positions, the index marks on the scanning frame and the pipe must be aligned.<br>• The chart shall then be compared to circumferential distance measured with a diameter tape; chart accuracy shall be within ±1 cm or better. |
| Temperature Control | • The Contractor shall maintain a stable transducer wedge temperature between the calibration scan and scanning the weld. This shall be monitored using a thermocouple embedded in a dummy transducer within the array, or in one of the active transducer wedges used in conjunction with a digital temperature gauge.<br>• The difference between the temperature of the transducers on the production weld and the temperature of the transducers when scanning the calibration block shall be monitored and must be within 50°F (10°C) variance.<br>• The temperature shall be recorded on all the hard copy printouts and be present in the electronic data. Alternative wedge property monitoring techniques may be considered by the Company prior to mobilization.<br>• For testing at temperature extremes in very hot or very cold conditions, the calibration block may need to be heated or cooled so that the array is maintained within a 50°F (10°C) variance when completing calibration in, weld scan, and calibration out cycles. |

### 2.5.6 Re-Examination

Table 2-7 outlines the conditions in which re-examination is required.

**Table 2-7: Re-Examination Conditions**

| Item | Details |
|---|---|
| Calibration Qualification and Sensitivity | Welds examined that do not meet the requirements of Section 2.4.3 of this Specification shall be re-inspected. |
| Coupling Losses | Welds examined exhibiting coupling losses with a length exceeding 12 mm or adjacent coupling sequences shall be re-inspected. |
| Scanner Slippage | Scans shall not be acceptable where any slippage occurs. Where slippage is noted, the scanner shall be adjusted to correct the problem and the scan shall be repeated. |
| Weld Repairs | Repaired areas shall be tested by automated ultrasonic examination using the appropriate SMAW configuration, or if not practicable, by using manual ultrasonic testing per APPENDIX C of this Specification. |
| Temperature Variance | Welds examined that do not meet the requirements of Section 2.5.5 of this Specification shall be re-inspected. |
| Other Conditions | When conditions exist where data collection is impaired or data is lost, the weld shall be re-tested with no additional compensation to the Contractor. The operator shall write down the reason for impaired data and relay that to the Company. |

## 2.6 Evaluation of Indicators

Automated Ultrasonic Weld Examination should be performed at a scanning sensitivity of 80% screen height reference sensitivity plus 4 dB when using the pulse-echo technique, as stated above. Evaluation sensitivity should be the same as scanning sensitivity. Evaluation level screen height (recording threshold) should be 40% of full screen height using the automated pulse-echo technique. Other automated techniques, reference reflectors, evaluation sensitivities, and evaluation levels may be used if demonstrated to be equivalent to the pulse-echo technique for the detection and evaluation of weld imperfections.

### 2.6.1 Imperfections

All welds will be inspected initially to API 1104 Section 9.6; if the weld fails that criteria for reasons other than a crack, the weld may then be evaluated to API 1104 – Appendix A, "Alternative Acceptance Criteria" (refer to DOT Regulations 49 CFR Part 192.241 or CFR 195.228, as appropriate).

Indications from weld imperfections shall be evaluated according to defect acceptance criteria defined by the Company using an Engineering Critical Assessment carried out according to API 1104, Appendix A.

Evaluations shall be completed immediately after examination of the weld. Failure to meet the API 1104 – Appendix A, "Alternative Acceptance Criteria" will then require weld repair and re-examination.

When evaluating imperfections following the acceptance criteria detailed in Section 9.6.2 of API 1104, the length of imperfections shorter than the width of the interrogating sound beam shall account for beam spread. For imperfections longer than the interrogating

beam width, the point where the signal reduces to the 40% reporting threshold shall be considered the end of the imperfection.

When evaluating imperfections following the API 1104, Appendix A length interaction criteria, the ends of the indications are to be determined from the points where the signal reduces in amplitude to two times the background noise level.

For imperfections assessed to the acceptance criteria using only the data recorded in the volumetric sequences, that assessment shall be limited to porosity imperfections. Imperfections from inter-pass incomplete fusion must be assessed at a sensitivity level corrected to be equivalent to 40% of full screen height when the peak signal response from a target 2 mm FBH is 80% of full screen height.

### 2.6.2 Shielded Metal Arc Welding (SMAW) Root Zone Buried vs. Open Surface Classification

Indications in the 70˚ root sequence must have a corresponding signal ≥ 6 dB in 60˚ root sequence to be interpreted as surface breaking, in addition to meeting the following requirements. Indications occurring simultaneously in root 60˚ and root 70˚ sequences must have the transit times compared to the calibration notch transit times to aid correct classification as buried or surface breaking. Indications occurring > 0.5 mm prior to the respective notch Time of Flight (TOF) time must be reviewed in the A-scan map display. The indication must to be classed as buried if there is a simultaneous signal evident from the face of the root bead. The highest amplitude in the defect area will be evaluated. Multiple indications will be assessed separately.

## 2.7 Records and Reports

Table 2-8 outlines the record and report requirements for utrasonic examination of girth welds.

**Table 2-8: Record and Report Requirements**

| Topic | Description |
|---|---|
| Weld Examination Record | • An electronic copy record of each weld and calibration scan shall be provided to the Company.<br>• The Contractor shall supply the Company the raw data for both calibration and weld scans daily for ongoing audit purposes.<br>• Where practicable, this data shall be uploaded to a suitable electronic file transfer site FTP which the Company auditor has internet access to.<br>• When the Contractor has no internet access, the raw data for both calibration and weld scans for a period no longer than 3 production days shall be copied to suitable electronic storage device and provided to the Company auditor. |
| Interpretation of Weld Examination Record | • Areas in the AUT data with a corresponding pulse-echo response will be evaluated and given a disposition by the operator as to relevant/non-relevant indication. This area will be highlighted on the strip chart and have an associated comment in the comments section of the AUT data.<br>• Areas with signals resulting from weld geometry only need highlighting in the data when |

| Topic | Description |
|---|---|
| | their length exceeds the acceptable imperfection length. |
| Weld Acceptance from Examination Record | • A weld shall be considered acceptable when the weld examination shows imperfections that do not exceed the acceptable values, as given by the Company. Acceptable values are provided either in the contractor or prior to the start of work.<br>• The Contractor shall submit ultrasonic weld interpretation reports to the Company daily, as directed by the Company.<br>• The Contractor shall ensure that all electronic data files and electronic files are further identified with the following:<br>▪ Spread Identification<br>▪ Project name<br>▪ Work order number<br>▪ Date & time<br>▪ Operator's name & signature<br>▪ Examination Unit Number<br>▪ Weld number & type (weld configuration/transition)<br>▪ Pipe material, diameter, and wall thickness<br>▪ AUT Procedure<br>▪ Acceptance criteria (ECA/Workmanship)<br>• All reporting shall be catalogued by consecutive weld number in binders |
| Data Management | • Back-ups of all electronic data shall be made for audit purposes on a daily basis with a minimum of two back-ups of each file on separate mass storage media.<br>• The working computer system disk shall not be considered as a back-up. |
| Report Guidelines | • Equipment performance logbooks, daily reports (Weld Log), and Repair Lists will be presented to the Company in hard copy and/or electronic format.<br>• Evaluation of the acceptability of every weld examination shall be reported on the "NDE Daily Report". The NDE Daily Report form will be the only form used for NDE (UT, VT, RT, MT, and PT) for weld accepted/rejected status.<br>• The Contractor will ensure that GPS/Chainage coordinates are recorded with the applicable weld information on NDE Daily Report for all tie-ins, repair welds and every 650 feet (200m) intervals for main and poor boy, if applicable.<br>• The NDE Supervisor shall collect all reports from the NDE Inspectors and document weld status in a database. |
| Archives | • No later than 3 months after completion of the project, a copy of all of the raw weld and calibration data shall be packaged together with a weld interpretation log and a raw data viewer program to provide an archive record.<br>• The viewer software shall allow reconstruction of the weld data files in an identical manner to that viewed by the system operator at the time of examination. |

Table 2-9 outlines the supporting documentation required for the above.

**Table 2-9: Required Supporting Documentation**

| Record Type | Requirements |
|---|---|
| Calibration Standard Records | • specific pipe details<br>• acoustic velocity reports<br>• dimensions, position, and angle of reference reflectors<br>• metrology records |
| Transducer Records | • make, date of manufacturing, and serial number<br>• nominal dimensions<br>• nominal frequency<br>• height & wear<br>• performance records |
| Ultrasonic System Records | • system description<br>• make & model number of units<br>• operating procedure<br>• technique(s) detailed<br>• operator log<br>• consistency calibrations<br>• performance tests, e.g. signal to noise, linearity, and element continuity tests |
| System Operator Records | • copy of certifications<br>• copy of eye exams<br>• copy of experience records |

### 2.7.1 Weld Repair List

Weld repair lists shall be provided to the Company in electronic and or hard copy format each working day. The time shall be specified by the Company and agreed to by the Contractor.

Repair lists shall report the weld quality, including outstanding weld repairs and/or weld cut-outs, of all welds completed by the prime Contractors' mainline welding crew. The daily cut off time shall be specified by the Company and agreed to by the Contractor.

## 3 VARIANCES

Any deviation must follow the appropriate TransCanada Management of Change (MOC) Variance Procedure (EDMS No. 7728702).

## 4 ROLES AND RESPONSIBILITIES

Table 4-1 below outlines the roles and responsibilities required for the use of this Specification.

**Table 4-1: Roles and Responsibilities**

| Role | Responsibilities |
|---|---|
| Company | The Company is responsible for:<br>• Ensuring all relevant information is provided to the Contractor(s) and Operator(s)<br>• Oversight on all Ultrasonic Examinations |
| Contractor | • The Contractor is responsible for ensuring all relevant requirements of this Specification and all other relevant documents are met. |
| Supervisor | • The Supervisor shall be responsible for the conduct and performance of all ultrasonic personnel and for maintaining all equipment and supplies in reliable condition.<br>• The Supervisor shall work closely with the Company's Senior Welding Inspector in the documentation of examinations completed and shall be responsible for all reports, interpretations, and evaluation.<br>• The NDE Supervisor shall audit daily the electronic data to ensure that interpretations are consistent, informative, and concise, and this Supervisor shall be capable of technical support for NDE operations. The extent of data audit shall be approved by the Company. |
| Ultrasonic Operator | The Ultrasonic Operator is responsible for ensuring all relevant requirements of this Specification and all other relevant documents are met. |

## 5 TRAINING AND QUALIFICATIONS

If required by the Company, the Contractor shall provide training (one day minimum) for Company Inspectors on the techniques of ultrasonic examination. This training shall be at a date and location determined by the Company and shall occur prior to the start of production welding.

Table 5-1 outlines the personnel qualifications for ultrasonic examination of girth welds.

**Table 5-1: Personnel Qualifications**

| Personnel | Qualifications |
|---|---|
| Supervisor | • The NDE Supervisor shall be approved by the Company based upon experience, technical knowledge, and NDE qualifications for the duties to be performed.<br>• Supervisors shall be qualified by examination and certified as a Level II or III in the "Ultrasonic" method in accordance with the requirements of ASNT-SNT-TC-1A, ACCP, or CP-189 and shall submit their records of certification.<br>• At a minimum, all Level III personnel shall be qualified to ANSI/ASNT Standard CP-189 or ACCP in the Ultrasonic method, and shall submit their records of current certification. |

| Personnel | Qualifications |
|---|---|
| Ultrasonic Operators | • The Company reserves the right to assess the competency of ultrasonic operators for manual examination using qualification welds containing defects.<br>• Ultrasonic operators must demonstrate their ability to detect and characterize typical indications and determine their acceptance according to the API 1104, Section 9.6.2 criteria and shall be approved by the Company. At the discretion of the Company, this process may be waived in lieu of an alternate approach.<br>• The Company shall be sole judge of operator performance.<br>• Ultrasonic operators shall be qualified by examination and certified as a Level II or III in the "Ultrasonic" method in accordance with the requirements of ASNT-SNT-TC-1A, CP 189 or ACCP, and shall submit their records of certification.<br>• Operators shall have completed a minimum of 40 hours training in automatic testing, including practical and theoretical aspects pertinent to the equipment and general configurations to be examined. This training shall be documented and the records shall be provided to the Company.<br>• An operator's project experience shall include stand-alone automated ultrasonic testing of a minimum 1000 pipeline girth welds.<br>• Alternate experience in lieu of the above requirements are subject to Company approval. |
| Contractors | • The Company will only use Contractors who have been approved in accordance with TEP-NDT-SQP System Qualification Procedure (EDMS No. 8906013). |

## 6 SAFETY CONSIDERATIONS

No incremental Safety Considerations are identified for this Specification.

## 7 ENVIRONMENTAL CONSIDERATIONS

No incremental Environmental Considerations are identified for this Specification.

## 8 GLOSSARY

Definitions related to this Specification can be found in Appendix D.

## 9 REFERENCES

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

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 9-1.

**Table 9-1: External and Internal References**

| Document No. | Title |
|---|---|
| **Legal Requirements** | |
| DOT 49 CFR Part 192 | Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards and any amendment, supplement, or errata issues by the United States Department of Transportation |
| DOT 49 CFR Part 195 | Transportation of Hazardous Liquids by Pipeline and any amendment, supplement, or errata issued by the United States Department of Transportation |
| **Industry Codes and Standards** | |
| API 1104 | Welding of Pipelines and Related Facilities |
| ANSI/ASNT-CP-189 | ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel |
| ASNT-SNT-TC-1A | ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel |
| ASTM E164 | Practice for Ultrasonic Contact Examination of Welds |
| ASTM E317 | Practice for Evaluation Performance Characteristics of Ultrasonic Pulse- Echo Testing Systems without the Use of Electronic Measurement Instruments |
| ASTM E494 | Practice for Measuring Ultrasonic Velocity in Materials |
| ASTM E316 | Standard Terminology for Non Destructive Examinations |
| ASTM E1961 | Standard Practice for Mechanized Ultrasonic Testing of Girth Welds Using Zonal Discrimination with Focused Search Units |
| BS EN 583-6: 2008 | Non-destructive testing. Ultrasonic examination. Time-of-flight diffraction technique as a method for detection and sizing of discontinuities |
| Electrical Supply Industry Standard ESI 98-2 Issue 1 Dec 1979/R1998 | Ultrasonic Probes: Medium Frequency Miniature Shear Wave, Angle Probes |
| BS EN 12668 | British Standard, Characterization and Verification of Ultrasonic Examination Equipment; Part 1 Instruments, Part 2 Transducers, Part 3 Combined Equipment |
| ASME Section V | Nondestructive Examination |
| **Internal References – Documents that Reference this Specification** | |
| EDMS No. 1001828336 | TEN-NDT NDT Standard (CDN-US-MEX) |
| EDMS No. 1001828218 | TES-WELD-API Welding of Pipelines and Facilities Specification (US-MEX) |

| Document No. | Title |
|---|---|
| EDMS No. 6717380 | TES-INSERV-API Welding on In-Service Pipelines Specification (US-MEX) |
| **Internal References – Documents Referenced by this Specification** | |
| EDMS No. 8906013 | TEP-NDT-SQP System Qualification Procedure |

## 10 DOCUMENTATION AND RECORDKEEPING

Table 10-1 details the documentation to be approved by the Company prior to System Mobilization. Refer to Section 2.7 for further details.

**Table 10-1: Documentation to be Approved by the Company Before System Mobilization**

| Item # | Documentation Required | TES-NDT-UT Reference | Company Representative Signoff |
|---|---|---|---|
| 1 | Project Specific Implementation Plan | 2.3.4 | |
| 2 | Quality Plan | 2.3.4 | |
| 3 | System and Operator Certifications | 5 | |
| 4 | General AUT Procedure | 2.3.2 | |
| 5 | Manual Ultrasonic Procedure | APPENDIX C | |
| 6 | Project Specific Examination Designs/Techniques | 2.1 | |
| 7 | Calibration Block Drawings | 2.3.1 | |
| 8 | Calibration Block Metrology and Ultrasonic Response Reports | 2.3.1 | |
| 9 | Pipe Material Acoustic Velocity Measurement Reports | 2.2 | |
| 10 | System Linearity Reports | 2.2 | |
| 11 | Ultrasonic Transducer Performance Reports | 2.4.3 | |
| 12 | Signal to Noise Reports | 2.2 | |

## 11 DOCUMENT HISTORY

| Rev. | | |
|---|---|---|
| 00 | **Description** | **Effective Date** |
| | Revised document developed as part of Engineering Standards Streamlining Process. | 2016-11-01 |
| | **Rationale Statement** | **Responsible Engineer** |
| | This document was revised in order to address the following requirements:<br>• Alignment with new document definitions, structure, and templates. | Simon Hsu<br>Sr. Welding Engineer |
| | **Impact Assessment Summary** | **Document Owner** |
| | This Specification was revised to streamline the documentation required for the NDE group and to make it more easily accessible to those who use it. | Simon Hsu<br>Sr. Welding Engineer |

## 12 DESCRIPTION OF CHANGE

| Section | Description of Change |
|---|---|
| **Regulatory** | |
| N/A | N/A. |
| **Industry Standards** | |
| N/A | N/A. |
| **General** | |
| N/A | This Specification is a new document. |

## 13 APPROVALS

| APPROVALS | | |
|---|---|---|
| Originator:<br>Salvatore Delisi, Senior Welding Technologist<br>Welding and Materials Engineering | Signature | Date: 10/27/16 |
| Reviewer:<br>Jason Althouse, Senior NDE Technologist<br>Welding and Materials Engineering | Signature | Date: 10/27/16 |
| Responsible Engineer:<br>Simon Hsu<br>Sr. Welding Engineer<br>Welding and Materials Engineering | Signature<br>Date: 10/27/2016 | |

# APPENDIX A EXAMINATION DESIGN REQUIREMENTS GAS METAL ARC WELDS (GMAW)

## A-1 PURPOSE

This appendix details the examination design requirements for automated ultrasonic examination of gas metal arc welds produced in the specified weld bevel.

## A-2 SCOPE

This appendix applies to mechanized ultrasonic examination of gas metal arc welds made with an internal root bead or with all passes deposited externally. This applies to pipe having a nominal wall thickness of 0.283 in. (7.2 mm) and greater.

## A-3 APPLICABLE STANDARDS

Ultrasonic examination shall also meet the requirements of API 1104 and any amendment, supplement, or errata issued by API.

## A-4 APPLICABLE WELD BEVEL

This design is applicable to mechanized gas metal arc weld bevel examination designs shown in Appendix Figure A-1.

## A-5 ULTRASONIC PARAMETERS

Ultrasonic parameters (transducer number, angle, frequency, beam size and position) shall be selected for each zone of the specified weld bevel, beginning in the weld root and finishing at the weld cap.

### A-5-1 ROOT ZONE

Welds with an Internal Root Bevel (37.5° Internal Bevel) and a weld pass deposited internally, see Appendix Figure A-1(a). One ultrasonic zone shall be required with the following parameters:

**Appendix Table A-1: Ultrasonic Zone Parameters (Root Zone (1))**

| Wall thickness | Angle (degrees) | Frequency (MHz) | Zone Size (mm) | Surface position |
|---|---|---|---|---|
| ≤ 0.314 in. (8 mm) | 52.5 ± 2.5 | min. 4<br>max. 8 | min. 2.0<br>max. 2.5 | 1.5 skip |
| > 0.314 in. (8 mm) | 52.5 ± 2.5 | min. 4<br>max. 8 | min. 2.0<br>max. 2.5 | 0.5 skip |

Weld with all Passes Deposited Externally (0° Land), see Appendix Figure A-1(b). One ultrasonic zone shall be required with the following parameters:

**Appendix Table A-2: Ultrasonic Zone Parameters (Root Zone (2))**

| Wall thickness | Angle (degrees) | Frequency (MHz) | Zone Size (mm) | Surface position |
|---|---|---|---|---|
| ≤ 0.314 in. (8 mm) | 70.0 ± 2.5 | min. 5<br>max. 6 | Min. 1.5<br>max. 2.0 | 1.5 skip |
| > 0.314 in. (8 mm) | 70.0 ± 2.5 | min. 5<br>max. 6 | min. 1.5<br>max. 2.0 | 0.5 skip |

## A-5-2 CROSS-PENETRATION ZONE

0° Bevel - Welds with an Internal Root Bevel only. Refer to Appendix Figure A-1(a) for bevel sketch. One ultrasonic zone shall be required with the following parameters:

| Wall thickness | Angle (degrees) | Frequency (MHz) | Zone Size (mm) | Surface position |
|---|---|---|---|---|
| ≤ 0.314 in. (8 mm) | 70.0 ± 2.5 | min. 5<br>max. 6 | min. 1.5<br>max. 2.0 | 1.5 skip |
| > 0.314 in. (8 mm) | 70.0 ± 2.5 | min. 5<br>max. 6 | min. 1.5<br>max. 2.0 | 0.5 skip |

**Appendix Table A-3: Ultrasonic Zone Parameters (Cross-Penetration Zone)**

## A-5-3 HOT PASS ZONE

Welds with an Internal Root Bevel (45° or 52° Hot Pass Bevel):

- For a hot pass with a bevel offset less than 2.5 mm, one ultrasonic zone is required with a -6dB beam size of 3.5 mm.
- For a hot pass with bevel offset of 2.5 mm and greater, this zone shall be divided in 2 sub-zones (refer to Appendix Figure A-1(a)) and two transducers shall be required with the following parameters.

**Appendix Table A-4: Ultrasonic Zone Parameters (Hot Pass Zone (1))**

| Wall thickness | Angle (degrees) | Frequency (MHz) | Zone Size (mm) | Surface position |
|---|---|---|---|---|
| ≤ 0.390 in. (10 mm) | min. 50<br>max. 55 | min. 4<br>max. 5 | min. 2.5<br>max. 3.0 | 1.5 skip |
| > 0.390 in. (10 mm) | min. 50<br>max. 55 | min. 4<br>max. 5 | min. 2.5<br>max. 3.0 | 0.5 skip |

Weld with all Passes Deposited Externally (Radius Hot Pass)

- Refer to Appendix Figure A-1(b) for bevel sketch. One ultrasonic zone shall be required with the following parameters:

**Appendix Table A-5: Ultrasonic Zone Parameters (Hot Pass Zone (2))**

| Wall thickness | Angle (degrees) | Frequency (MHz) | Zone Size (mm) | Surface position |
|---|---|---|---|---|
| ≤ 0.390 in. (10 mm) | min. 50<br>max. 55 | min. 4<br>max. 5 | min. 2.0<br>max. 2.5 | 1.5 skip |
| > 0.390 in. (10 mm) | min. 50<br>max. 55 | min. 4<br>max. 5 | min. 2.0<br>max. 2.5 | 0.5 skip |

## A-5-4 FILL(S) AND CAP ZONES[1]

The number of transducers for the fill(s) and cap zones, and their parameters, are linked directly to the pipe wall thickness. Typical bevel sketches are shown in Appendix Figure A-1.

For wall thickness < 0.314 in. (8 mm) one focused 70 ±2.5° shear wave transducer shall be used.

For wall thickness ≥ 0.314 in. (8 mm), but < 0.500 in. (12.7 mm):

- Two focused 70° (±2.5°) shear wave transducers, or a combination of one focused 65°- 70° shear wave transducer for the cap zone, and a single tandem arrangement for the fill zone shall be used.
- The -6 dB beam height selected for the cap zone shall have a dimension equal to or greater than the fill zone immediately below it.
- The preferred tandem configuration is shown in Appendix Figure A-2 and acceptable tandem combinations are specified in Appendix Table A-6.

No individual -6 dB beam size shall exceed 3.5 mm

For wall thickness ≥ 0.500 in. (12.7 mm) and larger:

- The cap zone shall be considered as having a 3.0 mm vertical extent and where practicable be inspected using a 65° to 70° (±2.5°) pulse echo, or creeping wave transducer, typically with a minimum -6 dB beam height of approximately 3.0 mm.

[1] For all wall thicknesses, the cap zone reference reflectors will consist of a 1 mm surface notch and a 2 mm FBH. The primary reference amplitude for the cap zone will be the response from the 2 mm FBH.

- The remaining bevel dimension extending from the top of the hot pass to the bottom of the cap zone (outside pipe surface minus 3 mm) shall be divided equally into fill sub-zones, with the following conditions:
  - The fill sub-zone immediately below the cap zone shall have a -6 dB beam height equal to or less than the cap zone dimension; and
  - No individual -6 dB beam size shall exceed 3.5 mm.
  - Each sub-zone shall be inspected using one of the suitable tandem combinations specified in.

**Appendix Table A-6: Tandem Configurations**

| Fill Bevel Angle (degrees) | Transmitter Angle (degrees) | Receiver Angle (degrees) |
|---|---|---|
| 4 | 38 - 50 | Transmitter Angle + 8 (46 - 58) |
| 5 | 38 - 48 | Transmitter Angle + 10 (48 - 58) |
| 6 | 38 - 46 | Transmitter Angle + 12 (50 - 58) |
| 7 | 38 - 44 | Transmitter Angle + 14 (52 - 58) |
| 8 | 38 - 42 | Transmitter Angle + 16 (54 - 58) |
| 9 | 38 - 40 | Transmitter Angle + 18 (56 - 58) |
| 10 | 42-48 | Transmitter Angle + 20 (62 - 68) |

## A-6 POROSITY TRANSDUCERS

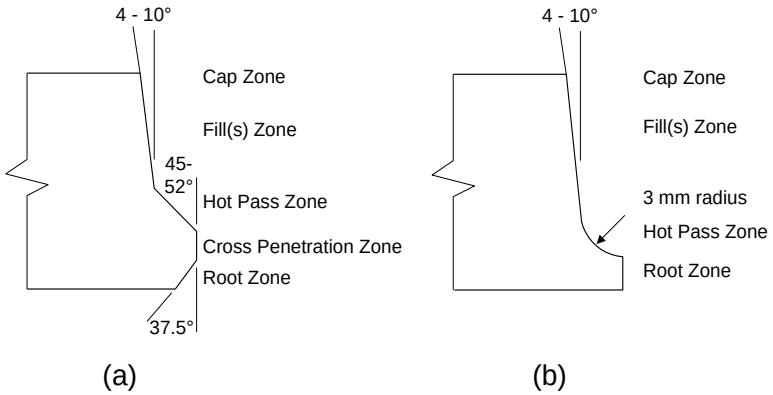
For the detection of porosity, the weld shall be divided into equal zones each not exceeding 3.5 mm, and examined using transducers with the following angles and frequencies:

- Root zone: One 65° to 72° transducer having a frequency between 5 and 7.5 MHz
- All other zones: 45° to 55° transducer/s having a frequency of 4.5 and 7.5 MHz.

## A-7 TRANSVERSE CRACK DETECTION (SEE FIGURE A-3)

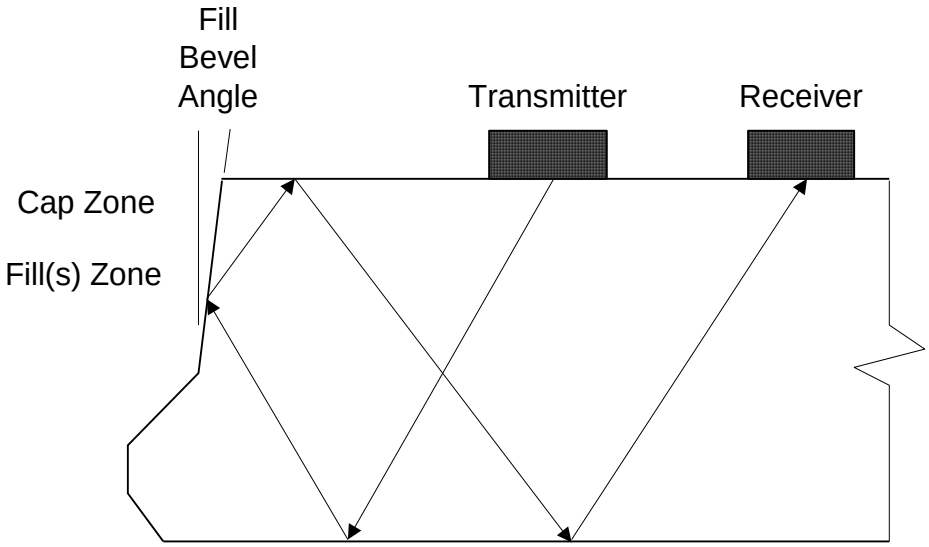
Two pairs of 45° to 70° transducers positioned at 20° to 60° from the weld axis in a cross-configuration shall be used to detect transverse cracks. The signal shall be sent from the transducer on the upstream side of the weld and received by the downstream transducer. One pair of transducers shall interrogate the upper half of the weld while the other pair interrogates the lower half. Coupling shall be monitored by sensing through-transmission diagonally across the weld.

## FIGURES



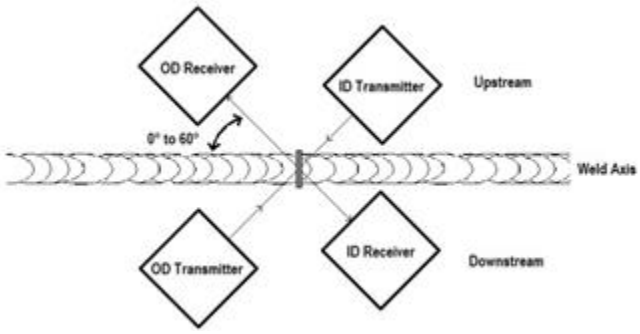

**Appendix Figure A-1: Bevel Designs**

**(a) Weld with Internal Root (b) Weld with all Passes Deposited Externally**




**Appendix Figure A-2: Preferred Tandem Sound Path**

Note: Shown for a weld with an internal root pass, same sound path for a weld with all passes deposited externally. When mechanically achievable the sound path should as short as practical; in the example above the receiver could be in front of the transmitter.




**Appendix Figure A-3: Sound Paths for Transverse Crack Detection**

# APPENDIX B EXAMINATION DESIGN REQUIREMENTS WELDS IN FACTORY BEVEL (SMAW & FCAW)

## B-1 PURPOSE

This appendix details the examination design requirements for automated ultrasonic examination of welds produced in the factory bevel.

## B-2 SCOPE

This appendix applies to mechanized ultrasonic examination of arc welds made in pipe having a nominal wall thickness≥ 6.4 mm.

## B-3 APPLICABLE STANDARDS

Ultrasonic examination to this procedure shall also meet the requirements of API 1104 and any amendment, supplement, or errata issued by API.

## B-4 APPLICABLE WELD BEVEL

This design is applicable to the standard end preparation of pipe as shown in Appendix Figure B-1 of this document.

## B-5 ULTRASONIC PARAMETERS

Ultrasonic parameters (transducer number, angle, frequency, beam size and position) shall be selected for each zone of the specified weld bevel, beginning in the weld root and finishing at the weld cap.

## B-6 ROOT ZONE (0° BEVEL)

Two ultrasonic zones shall be required with the following parameters:

**Appendix Table B-1: Ultrasonic Zone Parameters (Root Zone)**

| Wall thickness | Angle (degrees) | Frequency (MHz) | Zone Size (mm) | Surface position |
|---|---|---|---|---|
| ≤ 0.314 in. (8 mm) | 70.0 ± 2.5 | min. 5<br>max. 6 | min. 1.5<br>max. 2.5 | 1.5 skip |
| | 60.0 ± 2.5 | | | |
| > 0.314 in. (8 mm) | 70.0 ± 2.5 | min. 5<br>max. 6 | min. 1.5<br>max. 2.5 | 0.5 skip |
| | 60.0 ± 2.5 | | | |

## B-7 HOT PASS ZONE (30° BEVEL)

One ultrasonic zone shall be required with the following parameters:

**Appendix Table B-2: Ultrasonic Zone Parameters (Hot Pass Zone)**

| Wall thickness | Angle (degrees) | Frequency (MHz) | Zone Size (mm) | Surface position |
|---|---|---|---|---|
| 0.314 in. (8 mm) | 60.0 ± 2.5 | min. 4<br>max. 6 | min. 2.5<br>max. 3.5 | 1.5 skip |
| 0.314 in. (8 mm) | 60.0 ± 2.5 | min. 4<br>max. 6 | min. 2.5<br>max. 3.5 | 0.5 skip |

## B-8 FILL(S) AND CAP ZONES

The number of transducers for the fill(s) and cap zones, and their parameters, are linked directly to the pipe wall thickness.

B-8-1 WALL THICKNESS < 0.354 IN. (9 MM)

Two focused 60±2.5° transducers shall be used.

No individual -6 dB beam size shall exceed 3.5 mm.

B-8-2 WALL THICKNESS ≥ 0.354 IN. (9 MM)

The number of sub-zones (n), and focused 60V (±2.5°) shear wave transducers and their -6 dB beam heights shall be determined by the formula:

$$n = (WT – RH) / (\cos (A)*h) = (WT – 3) / (0.866*h)$$

where, A is the bevel angle (30° for a standard bevel), WT is the wall thickness in mm, RH is the vertical displacement to account or the root and hot pass (assumed as 3 mm), and h is -6 dB beam height such that:

No individual -6 dB beam size shall exceed 3.5 mm.

## B-9 POROSITY TRANSDUCERS

For the detection of porosity, the weld shall be divided into equal zones each not exceeding 3.5 mm, and examined using transducers with the following angles and frequency.

- Root zone: One 60˚ or 70° transducer having a frequency between 5 and 7.5 MHz.
- All other zones: 45˚ to 55° transducers having a frequency of between 5 and 7.5 MHz.

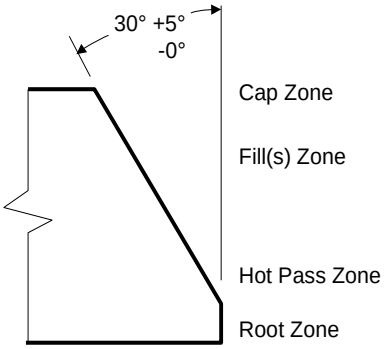
## B-10 TIME OF FLIGHT DIFFRACTION (TOFD)

For a given pipe wall thickness, the transducer angle, frequency and damping characteristics shall be selected to optimize detection and to limit the depth of the lateral wave below the surface to a maximum of 4 mm, giving consideration to the index-to-index spacing and the maximum width of the weld reinforcement.

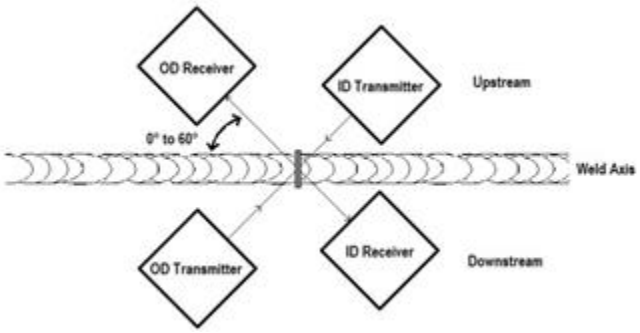
## B-11 TRANSVERSE CRACK DETECTION (SEE FIGURE B-2)

Two pair of 45° to 70° transducers positioned at 20° to 60˚ from the weld axis in a cross configuration shall be used to detect transverse cracks. The signal shall be sent from the transducer on the upstream side of the weld and received by the downstream transducer. One pair of transducers shall interrogate the upper half of the weld while the other pair interrogates the lower half. Coupling shall be monitored by sensing through-transmission diagonally across the weld.

**FIGURES**




**Appendix Figure B-1: Standard Bevel Design**




**Appendix Figure B-2: Sound Paths for Transverse Crack Detection**

# APPENDIX C REQUIREMENTS FOR MANUAL ULTRASONIC EXAMINATION OF WELDS

## C-1 SCOPE

This Appendix applies to all pipeline assets, which are wholly owned and operated by TransCanada, as well as all partially-owned entities and/or joint ventures where TransCanada has operational control.

This Appendix applies to shear wave ultrasonic examination of welds made in pipe and/or plate having a nominal wall thickness greater than or equal to 0.250 in. (6.4 mm). When application of this appendix is utilized for pipeline girth weld repairs, the examination method originally used must verify defect removal prior to manual UT. Examination of wall thicknesses below 0.250 in. (6.4 mm) shall be addressed in a procedures provided by the NDE Vendor to the Company and approved by Materials and Welding Engineering prior to performing examinations.

## C-2 NDE TECHNICIAN QUALIFICATION REQUIREMENTS

The Company shall have the right to examine the qualifications of all non-destructive testing personnel and to exclude individuals that, in the opinion of the Company, lack necessary training or experience for the work, or have demonstrated an inability to adequately perform the prescribed examinations. This evaluation may be in the form of the review of NDE technician qualification documents by Materials and Welding Engineering, via review of project documentation, or by direct observation. A Company authorized representative may also perform this evaluation. Incompetence or lack of diligence at any time may result in immediate termination from the project.

For the minimum qualification for personnel, referred to herein as Level II Ultrasonic Testing technicians, the following requirements shall be met:

- Personnel undertaking ultrasonic testing shall be qualified under TransCanada's Operator Qualification (OQ) program; in addition, they require certification to Level II or III of SNT-TC-1A, CP 189 or ACCP requirements.
- The status of NDE personnel indicating certifications obtained directly from ASNT can be verified here: https://asnt.org/certificant. Employer based NDE certifications WILL NOT be indicated on this website.
- Evidence of current Operator Qualification shall be provided to the Active Controller prior to work being performed. In the U.S., Company operator qualification records for Covered Tasks Veriforce Task ID 206 – Nondestructive Testing of Welds (Ultrasonic) shall be obtained from the NDE vendor or verified by confirmation on VeriSource website [https://www.veriforce.net/vs/login.aspx].

## C-3 EQUIPMENT

The following equipment shall be available to perform the examination:

- Portable ultrasonic flaw detector having a linear presentation which meets the requirements of ASME Section V, Article 5.

- International Institute of Welding, IIW Type 1, or Type 2, calibration block.
- Transducers having a nominal frequency between 3.5, and 6.5 MHz, with an active crystal dimension no greater than 0.500 in. and refracted angles of 45°, 60°, and 70°. Transducers may be either a fixed configuration, or removable wedge types; where pure volumetric scanning is performed focused probes shall not be used. Where accurate defect height sizing is required focused transducers shall be used.
- Project specific ultrasonic calibration block containing 10% of wall thickness square notches (N10), one on OD and one on ID surfaces; a 0.100 in. diameter side drilled hole located at ½ wall thickness. Notches shall be separated by a minimum of 3.1 in. See API 1104 Section 11.4
- Couplant shall be water or a water-based gel; no oil based products shall be used. For cold weather application methanol may be added; the methanol mix must be recovered.

## C-4 PROCEDURES

Ultrasonic examination shall be performed in accordance with a documented, detailed procedure, technique approved by the Company. A written procedure or technique sheet and instructions for each thickness and variation shall be produced which meets the requirements of API 1104, Section 11.4.2.2.

The ultrasonic technique shall be acceptable for the intended application. The Company reserves the right to judge of the adequacy of the technique for the intended use.

## C-5 EQUIPMENT SET-UP

The equipment shall be set up and the weld scanned as follows:

- Transducers shall be as specified in the table below for the wall thickness to be examined.

**Appendix Table C-1: Transducer Selection Criteria**

| Wall thickness (in.) | Examination Angles |
|---|---|
| Smaller than 0.375 | 70° |
| 0.375 – 0.750 inclusive. | 60 and 70° |
| Larger than 0.750 | 45, 60 and 70° |

- Calibrate the range to represent a minimum distance of one and one half skip in the pipe material.
- With the project specific calibration block, produce a 3 point distance amplitude correction curve (DAC) using the N10 notches and adjust gain to produce peak DAC amplitude of 80 % FSH. At a distance of ¾ skip maximize the response from the 0.100 in side drilled hole, if the hole response is below DAC then adjust gain to produce an 80 % of FSH response.

When a project specific calibration block is not available, a similar calibration block may be utilized providing is transfer correction is determined and applied to the sensitivity as determined in the same method described in step (c).

## C-6 EXAMINATION OF WELDS

### C-6-1 BASE METAL EXAMINATION

A compression wave test of the parent material on both sides of the weld (minimum distance = 1.25, times the longest surface skip distance) shall be performed. All interfering partial and full beam reflectors shall be noted (datum location and distance from the weld edge) and recorded on the examination record.

Using a longitudinal wave transducer, adjust the second back-wall echo in the base material to at least 80 % of FSH and examine for laminar or stringer imperfections which may interfere with the transverse wave examination. All significant imperfections shall be recorded and, where practical, the transverse wave examination shall be modified to compensate for their presence. The area to be examined shall cover 100 % of the base metal though which the transverse wave will pass.

### C-6-2 WELD METAL EXAMINATION

Manual ultrasonic weld testing shall be performed at a scanning sensitivity of DAC/TCG reference sensitivity plus 6 dB minimum. All indications that exceed 50% of DAC/ TCG screen height shall be evaluated. Evaluation sensitivity for manual ultrasonic weld testing should be DAC/TCG reference sensitivity plus 6 dB with an evaluation level for all indications at 50% of DAC/TCG screen height. After the reference sensitivity, scanning sensitivity, and evaluation sensitivity and levels have been established, they shall be qualified then incorporated into the final procedure and the final qualification report.

A 100% volumetric examination of weld metal and HAZ shall be performed. Examination techniques shall include:

- Add 6 dB of additional sensitivity for scanning purposes.
- Scan 100 % of the weld area using a zigzag scan pattern with the axis of the beam perpendicular to the weld.
- Ensure that the scan raster provides for a minimum 30 % overlap of the beam width.

### C-6-3 EVALUATION

Indications exceeding 50 % DAC shall be evaluated as follows:

- The characteristic echo-dynamic behavior shall be used to classify the imperfection type.
- The through-wall location of the imperfection shall be determined by maximizing the signal response and calculating the depth using trigonometry.
- The length of the imperfection shall be measured using the 6 dB drop method and compared to the requirements of API 1104, Section 9.6.

## C-7 AUDIT, AUDITOR, AND RIGHT TO AUDIT

All NDE operations are subject to audit by the Company. NDE audits shall be planned and conducted by a Company auditor with appropriate qualifications in non-destructive examination, on a periodic but random basis, to verify compliance with Specification and Contract requirements. The Company auditor shall have the right to examine all procedures, reports, and equipment both during and after method performance, complete an audit report, recommend disposition of any nonconformance, and suggest appropriate corrective actions when required. If the Company audit finds a required corrective action, these findings shall be addressed in a timely manner.

## C-8 REPORTS

Defects found during examination shall be reported on the appropriate Contractor report form having a minimum of the following details:

- Weld identification
- Defect classification
- Defect length
- Location of the defect in the through thickness, with reference to the OD surface
- Side of the weld: upstream or downstream
- Position of the start of the defect from the top dead center of the weld in a clockwise direction when viewing the pipeline in the construction direction
- Maximum response from the defect expressed as a percent of FSH at reference gain setting
- General details, equipment used, operator identity and qualification level, date, and time
- Sketch
- Job number

## APPENDIX D TERMS AND DEFINITIONS

| Term | Definition for Terms |
|---|---|
| **Active Controller** | TransCanada's on-site lead technician |
| **APEGA** | Association of Professional Engineers and Geoscientists of Alberta |
| **Authorized Representative** | Individual designated by Materials Engineering to represent the Company for matters covered by this Specification. |
| **ASME** | American Society of Mechanical Engineers |
| **Company, TCPL** | TransCanada PipeLines Limited (Company) including their engineering agencies, inspectors and other authorized representatives. |
| **Contractor** | The ultrasonic inspection contractor engaged to perform work covered by this Specification. |
| **DAC** | Distance Amplitude Correction |
| **dB (Decibel)** | The dB is a logarithmic unit that describes a ratio of two measurements used in ultrasonic methods |
| **FSH (Full screen height)** | FSH is a measurement based upon a calibrated screen |
| **HAZ (Heat-affected Zone)** | Heat affected zone indicates the area which the welding process has changed the metallurgical properties of the parent material |
| **NDE** | Non-destructive Examination |
| **Operator(s)** | Operators of ultrasonic equipment. Ultrasonic operators shall be qualified and certified in accordance with the requirements of Level II Canadian General Standards Board, CAN/CGSB 48.9712 Qualification and Certification of Nondestructive Testing Personnel. |
| **Operator(s)** | Operators of ultrasonic equipment. Ultrasonic operators shall be qualified and certified in accordance with the requirements of Level II ASNT-SNT-TC-1A as a minimum and shall submit their records of certification. All operators shall be approved by the Company prior to the start of any work and shall qualify by demonstrating their ability to operate and interpret the results obtained from their ultrasonic inspection system. The qualification test shall be administered and witnessed by the Company prior to production welding. |
| **Pipeline** | A pipeline for the transmission of natural gas or hazardous liquids including laterals, branch connections, extensions, compressors, pumps, and related facilities as defined by 49 CFR 195, "Transportation of Hazardous Liquids by Pipeline" or by 49 CFR 192 "Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards" |

| Term | Definition for Terms |
|---|---|
| **TOP** | TransCanada Operating Procedure |
| **Vendor** | Any outside source hired by the Company to complete work |

## PURPOSE

This standard provides the key requirements for materials design, selection, and use.

## SCOPE

This standard applies to the materials engineering design, selection, and use of all new high-pressure and low-pressure, non-sour, natural gas pipeline, compression, and metering facilities and non-sour liquid hydrocarbon pipeline, pump, metering and terminal facilities owned and operated by TransCanada in Canada, the United States, and Mexico.

This Standard does not apply to modifications to existing systems. For modifications to existing systems, the Designer shall determine the best practices providing that the modifications meet the intent of the current design requirements, and the requirements of the applicable regulations and industry standards.

This Standard does not include material requirements for the Energy business line.

The Responsible Engineer shall be contacted for clarification if needed.

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# 1 MATERIALS INFORMATION REQUIRED

This Standard provides the basis for materials selection and use in engineering design based on system pressure rating, design temperature, fracture toughness requirements, heat treatment requirements, manufacturer welding requirements, manufacturer NDE requirements, and equipment specific factors.

All general design requirements are provided in this Standard while all equipment specific factors are outlined in the referenced Specifications.

## 1.1 Pressure Rating

The Designer shall confirm the pressure rating of the system based on the following limits:

- Low-pressure systems: designed for pressures below PN 20 (1900 kPa) / ASME Class 150 (276 psi).
- High-pressure systems: designed for pressures at and above PN 20 (1900 kPa) / ASME Class 150 (276 psi).

These limits are subject to the specific project requirements and may be adjusted to suit project requirements in consultation with the Company's Materials Engineering department.

## 1.2 Design Temperature

The Designer shall verify the minimum design metal temperature (MDMT) based on the system region (outlined in Table 1-1 below). The MDMT for the U.S. is split into two zones (north and south) based on American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) data. Refer to APPENDIX C for a map of the temperature zones. The MDMT for Mexico is the same as that of U.S. south zone (Zone 2).

The Designer may specify a different MDMT based on sound engineering judgment in consultation with the Company's Materials Engineering department.

**Table 1-1: Standard Minimum Design Temperature by Region**

| Country | Zone | Standard MDMT: Belowground piping | Standard MDMT: Components and Aboveground piping |
|---|---|---|---|
| Canada | - | -5°C (+23°F) | -45°C (-50°F) |
| US | Zone 1 | -5°C (+23°F) | -45°C (-50°F) |
| | Zone 2 | 0°C (+32°F) | -29°C (-20°F) |
| Mexico | - | 0°C (+32°F) | -29°C (-20°F) |

## 1.3 Fracture Toughness Requirements

Fracture control is achieved by using materials with demonstrated Charpy V-Notch (CVN) absorbed energy at or below the MDMT. The minimum absorbed energies shall be as per the applicable materials specification or industry standard.

- **Note:** Pressure containing components NPS 4 and larger, with an MDMT other than -45°C (-50°F) (e.g., Zone 2 or site specific design), may actually be tested at -45°C (-50°F) as this is the required standard impact test temperature in most industry materials standards.

For the U.S. and Mexico, pipe and components equal or larger than NPS 4 with proven fracture toughness (demonstrated by CVN absorbed energy) are preferred for use in gas and liquids pipeline systems to enhance safe operation or to facilitate redeployment of materials to other projects.

Requirements are outlined below in Table 1-2 for liquid systems and Table 1-3 for gas systems.

**Table 1-2: Fracture Toughness Requirements for Liquid Systems**

| Part | Size | Requirements | |
|---|---|---|---|
| | | Canada | U.S. and Mexico[1] |
| Components | < NPS 4 | Not required. | Not required. |
| | ≥ NPS 4 and < NPS 16 | Proven fracture toughness required. | • In Zone 1, proven fracture toughness is required.<br>• In Zone 2, component materials without proven notch toughness are permissible where allowed by industry codes or standards. |
| | ≥ NPS 16 | Proven fracture toughness required. | Proven fracture toughness required. |
| Pipe | All | To facilitate use for other projects if necessary, consideration should be given to procuring pipe with a shear area requirement as determined through drop weight tear testing (for pipe > NPS 18) or Charpy V-notch testing (for pipe ≤ NPS 18) in accordance with the requirements CSA Z245.1, Category II requirements (Canada) or API 5L (U.S. and Mexico). | |
| | < NPS 4 | Not required. | Not required. |
| | ≥ NPS 4 | Proven fracture toughness required. | Proven notch toughness at or below the MDMT is required for all carbon steel pressure containing pipe with a nominal size of NPS 16 and larger or when designed to be operated at a hoop stress of more than 20% SMYS (specified minimum yield strength) at the lower of 32°F or the MDMT as per ASME B31.4 paragraph 423.2.3. |

**Notes:**

[1] Proven notch toughness is not mandatory for low-pressure facilities as defined in Section 1.1 of this Standard.

**Table 1-3: Fracture Toughness Requirements for Gas Systems**

| Part | Size | Requirements | |
|---|---|---|---|
| | | Canada | U.S. and Mexico |
| Components | < NPS 4 | Not required. | Not required. |
| | ≥ NPS 4 and < NPS 16 | Proven fracture toughness is required. | Unless otherwise approved by Materials Engineering, proven fracture toughness is required for components when the MDMT is below -20°F (-29°C). |
| | ≥ NPS 16 | Proven fracture toughness is required. | Proven fracture toughness is required. |
| Pipe | < NPS 4 | Not required. | Not required if it is designed to operate at hoop stress below 72% of SMYS |
| | ≥ NPS 4 and ≤ NPS 18 | For continuous piping runs[1] 100m (330 ft) or longer, demonstrated shear area from CVN testing at or below the MDMT is required. | |
| | | Proven fracture toughness is required. | Proven fracture toughness is required if:<br>• Pipeline is designed to operate at hoop stress over 72% of SMYS, or<br>• Pipes are designed with MDMT below -20°F (-29°C), or<br>• Pipe has a nominal size of NPS 16 and larger. |
| | > NPS 18 | For continuous piping runs[1] 100m (330 ft) or longer, demonstrated shear area from drop-weight tear testing (DWTT) at or below the MDMT is required. | |
| | | Proven fracture toughness is required. | Proven fracture toughness is required. |

**Notes:**

[1] Defined as continuous pipe sections where the pipe has the same nominal wall thickness and there are no components.

## 1.4 Heat Treatment Requirements

The requirements in Table 1-4 apply to verification of heat treatment for carbon steel components for all jurisdictions.

**Table 1-4: Heat Treatment Verification Requirements**

| Specified Minimum Yield Strength | Requirements |
|---|---|
| < 359 MPa (52 ksi) | No heat treatment verification is required. |
| ≥ 359 MPa (52 ksi) | Materials Engineering shall verify compliance with the heat treatment procedures and controls of the applicable materials specification or industry standard.<br>**Exception:** No resubmission of heat treatment procedures is necessary for manufacturers approved by Materials Engineering because the review and approval of these procedures are addressed during the qualification process. |

### 1.5 Manufacturer Welding Requirements

All pressure containing welds and repair welds made by a manufacturer shall be performed using welders and welding procedures qualified in accordance with the applicable materials specification or industry standard. If no requirements exist, the procedures shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX or equivalent approved by the Company's Materials Engineering department.

Manufacturer welding procedure qualifications shall include CVN impact testing for the weld and heat affected zone (HAZ) as per the requirements of the applicable materials specification or industry standard. If no requirements exist, the CVN testing shall be done in accordance with Paragraphs UG-84 (g) and UG-84(h)(3) of ASME Boiler Pressure Vessel Code, Section VIII, Division 1.

### 1.6 Manufacturer NDE Requirements (items manufactured to Company specifications)

All pressure containing welds shall be examined using non-destructive examination (NDE) methods as per the applicable materials specification or industry standard. Critical sections in castings shall be examined using radiographic or ultrasonic methods in accordance with ASME Boiler and Pressure Vessel Code, Sec. V, Article 2 and Article 5, respectively. Welding ends of items shall be examined using liquid penetrant or magnetic particle methods in accordance with ASME Boiler and Pressure Vessel Code, Sec. V, Article 6 and 7, respectively.

## 2 MATERIALS REQUIREMENTS

Considering the factors addressed in Clauses 1.1 to 1.6, the Designer shall determine equipment-specific materials requirements based on the materials specifications and industry standards for piping and components listed in APPENDIX A and APPENDIX B. All materials covered in APPENDIX A and APPENDIX B shall be purchased from Approved Manufacturers (refer to Supply Chain department).

- TransCanada's proprietary material specifications shall be used where they are listed in APPENDIX A and APPENDIX B and where the Company is able to source the materials directly from a manufacturer.
- Where it is not possible to source the materials directly from a manufacturer, due to order size or availability of material, materials may be sourced from recognized/authorized distributors provided that:
    - The materials are from approved manufacturers, and
    - Applicable industry standards and Company technical requirements are met.

  Materials Engineering shall be consulted to ensure technical requirements are met in this case.

- Piping and components not listed in APPENDIX A and APPENDIX B shall be ordered to the applicable industry standards and do not need to be sourced from approved manufacturers.

## 2.1 Additional Guidance Documentation

The Designer should consult the following documents for details concerning materials selection and design:

- TEG-MDC-L (Canada, Liquids)
- TEG-MDC-G (Canada, Gas)
- TEG-MDU-L (US/Mexico, Liquids)
- TEG-MDU-G (US/Mexico, Gas)

The tables included in these documents are considered to be guidance. The Designer may select other materials than those listed in the supporting documents as long as the requirements of this standard are met.

It should also be noted that the materials listed in these documents are preferred or considered to be the most common but other equivalent materials may also be available (e.g. ASTM A105 in lieu of A234 WPB). Some listings reference the forged product specifications and the comparable casting product specifications (e.g. ASTM A216 WCB in lieu of A105 or A352 LCB in lieu of A350 LF2) would also be suitable. In addition, more stringent requirements may be applied at the discretion of the project.

## 2.2 Deviations from Requirements

Unique circumstances (i.e. outside of standard design conditions) may require the development of materials engineering requirements that are outside of the requirements of this standard. Consideration shall be given on a case-by-case basis for deviation from the requirements of this standard and will require Materials Engineering approval either through a project specific agreement or through the variance process (see Section 4). Deviations to TransCanada requirements may be accepted, but deviations from the requirements of the applicable regulations and industry standards are not acceptable.

# 3 COMPLETE TEST REPORTS AND TRACEABILITY

The following reports and traceability requirements must be met:

- NPS 2 or larger: Material Test Report
- Smaller than NPS 2: Material Test Report or Certificate of Compliance

All materials used shall be traceable to certified material test reports or certificates of compliance in accordance with the identification or marking requirements in the applicable materials specification.

## 4 VARIANCES

Any deviation must follow the appropriate TransCanada Management of Change (MOC) Variance Procedure (EDMS No. 7728702).

## 5 GLOSSARY

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

## 6 REFERENCES

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

Additional references may include general industry guidance as well as internal references. A complete list of applicable Legal Requirements is available in the TransCanada Legal Registry. These documents are detailed below in Table 6-1 and

Table 6-2.

**Table 6-1: External References by Topic**

| Document No. | Title | Applicability |
|---|---|---|
| **Legal Requirements** | | |
| NEB OPR SOR/99-294 | National Energy Board Onshore Pipeline Regulations | Canada, Natural gas and sweet liquid hydrocarbon pipelines and pipeline facilities |
| Various | Applicable Provincial Regulations for Provincially Regulated Systems | Canada, Natural gas and sweet liquid hydrocarbon pipelines and pipeline facilities |
| Code of Federal Regulations, Title 49 Part 192 | Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards | US, Natural gas pipelines and pipeline facilities |
| Code of Federal Regulations, Title 49 Part 195 | Transportation of Hazardous Liquids by Pipeline | US, Sweet liquid hydrocarbon pipelines and pipeline facilities |
| NOM-007-SECRE-2010 | Transport of Natural Gas (Transporte de Gas Natural) | Mexico, Natural gas and sweet liquid hydrocarbon pipelines and pipeline facilities |
| **Industry Codes and Standards** | | |
| CSA Z662 | Canadian Standards Association, Oil and Gas Pipeline Systems | Canada, Natural gas and sweet liquid hydrocarbon pipelines and pipeline facilities |

| Document No. | Title | Applicability |
|---|---|---|
| ASME B31.3 | American Society of Mechanical Engineers (ASME), Process Piping | When required, Canada, US and Mexico, facilities |
| ASME B31.4 | American Society of Mechanical Engineers (ASME), Pipeline Transportation Systems for Liquids and Slurries | US and Mexico, Sweet liquid hydrocarbon pipelines and pipeline facilities |
| ASME B31.8 | American Society of Mechanical Engineers (ASME), Gas Transmission and Distribution Piping Systems | US and Mexico, Natural gas pipelines and pipeline facilities |

**Table 6-2: External and Internal References (General)**

| Document No. | Title |
|---|---|
| **Industry Codes and Standards** | |
| CSA Z245.1 | Steel Pipe |
| CSA Z245.11 | Steel Fittings |
| CSA Z245.12 | Steel Flanges |
| CSA Z245.15 | Steel Valves |
| API 5L | Specification for Line Pipe |
| API 6D | Specification for Pipeline Valves |
| API 609 | Butterfly Valves: Double-flanged, Lug- and Wafer-type |
| ASME B16.5 | Pipe Flanges and Flanged Fittings |
| ASME B16.9 | Factory-Made Wrought Buttwelding Fittings |
| ASME B16.11 | Forged Fittings Socket Welding and Threaded |
| ASME B16.20 | Metallic Gaskets for Pipe Flanges, Ring-Joint Spiral Wound and Jacketed |
| ASME B16.21 | Nonmetallic Flat Gaskets for Pipes Flanges |
| ASME B16.25 | Buttwelding Ends |
| ASME B16.34 | Valves – Flanged, Threaded, and Welding End |
| ASME B16.47 | Large Diameter Steel Flanges |
| ASME B16.49 | Factory-Made, Wrought Steel, Buttwelding Induction Bends for Transportation and Distribution Systems |
| ASME BPVC-V | Boiler and Pressure Vessel Code, Section V, Nondestructive Examination |

| Document No. | Title |
|---|---|
| MSS SP-44 | Steel Pipeline Flanges |
| MSS SP-75 | Specification for High-Test, Wrought, Butt-Welding Fittings |
| MSS SP-83 | Class 3000 Steel Pipe Unions, Socket Welding and Threaded |
| MSS SP-95 | Swage Nipples and Bull Plugs |
| MSS SP-97 | Integrally Reinforced Forged Branch Outlet Fittings - Socket Welding, Threaded and Buttwelding Ends |
| **Internal References – Documents Referenced by this Standard** | |
| EDMS No. 8194414 | TES-FITG-B1 Induction Bends Specification (CDN-US-MEX) |
| EDMS No. 4424021 | TES-FITG-CIF Specification for Contoured Insert Fittings (CDN-US-MEX) |
| EDMS No. 3779256 | TES-FITG-EC1 End Closures Specification (CDN-US-MEX) |
| EDMS No. 3671270 | TES-FITG-LD Carbon Steel Buttwelding Fittings Specification (CDN-US-MEX) |
| EDMS No. 3779258 | TES-FITG-SAD Full Encirclement Reinforcing Saddles Specification (CDN-US-MEX) |
| EDMS No. 3671966 | TES-FLGE-LD Carbon Steel Buttwelding Flanges Specification |
| EDMS No. 4423389 | TES-FLGE-LD-US High Yield Carbon Steel Buttwelding Flanges Specification |
| EDMS No. 3670788 | TES-PIPE-EW Electric Welded Pipe Specification (CDN-US-MEX) |
| EDMS No. 3776714 | TES-PIPE-SAW Double Submerged Arc Welded Pipe Specification (CDN-US-MEX) |
| EDMS No. 1001891682 | TES-VALV-G Steel Valves For Gas Services Specification (CDN-US-MEX) |
| EDMS No. 1001895584 | TES-VALV-L Steel Valves for Liquid Service Specification (CDN-US-MEX) |
| EDMS No. 1001895758 | TES-VALV-TOV Triple Offset Valves Specification (CDN-US-MEX) |

## 7 DOCUMENT HISTORY

| Rev. | | |
|---|---|---|
| 00 | **Description** | **Effective Date** |
| | New document developed as part of Engineering Standards Streamlining Process. | 2016-Nov-01 |
| | **Rationale Statement** | **Responsible Engineer** |
| | This document was developed in order to address the following requirements:<br>• Provide a standard for the determination of Materials requirements. | Cindy Guan, P. Eng. |
| | **Impact Assessment Summary** | **Document Owner** |
| | This standard was created to streamline the documentation required for the Materials group and to make it more easily accessible to those using the underlying specifications. | Cindy Guan, P. Eng. |

## 8 DESCRIPTION OF CHANGE

| Section | Description of Change |
|---|---|
| **Regulatory** | |
| N/A | N/A. |
| **Industry Standards** | |
| N/A | N/A. |
| **General** | |
| N/A | This Standard is a new document. |

## 9 APPROVALS

| APPROVALS | | |
|---|---|---|
| Originator:<br>Derek Chen, P. Eng.<br>Welding and Materials Engineering | Signature | Date: Nov 1, 2016 |
| Reviewer:<br>Sajjad Kazi, P. E.<br>Welding and Materials Engineering | Signature | Date: Nov 1, 2016 |
| Responsible Engineer:<br>Cindy Guan, P. Eng.,<br>Welding and Materials Engineering | Signature<br>Date: NOV. 1, 2016 | PROFESSIONAL ENGINEER ALBERTA XINGSHENG (CINDY) GUAN APEGA Permit to Practice P7100 |
| Management Endorsement:<br>James Ferguson, Manager<br>Engineering Technical Governance | Signature | Date: Nov. 1, 2016 |

# APPENDIX A CANADIAN MATERIALS REQUIREMENTS FOR LIQUID AND GAS SYSTEMS

**Appendix Table A-1: Canadian Materials Requirements for Liquids and Gas Systems**

| Commodity | Size | Materials Specification | Industry Standards | Limitations |
|---|---|---|---|---|
| Pipe | ≥ NPS 16 | TES-PIPE-SAW<br>TES-PIPE-EW | CSA Z245.1, Category II; or<br>API 5L PSL 2 | • Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests.<br>• Above ground pipe should be sourced through integrity or station pipe orders directly from pipe mills. Pipe with Drop Weight Tear Testing (DWTT) below -18°C is very difficult to source from distributors. |
| | ≥ NPS 10 and < NPS 16 | TES-PIPE-EW | CSA Z245.1, Category II; or<br>API 5L PSL 2; or<br>ASTM A333 Gr. 6 | |
| | ≥ NPS 4 and < NPS 10 | N/A | | |
| Valves (Ball, Gate, Check, and Plug) | ≥ NPS 16 | TES-VALV-G (Gas)<br>TES-VALV-L (Liquids) | CSA Z245.15, Category II; or<br>API 6D | • Impact testing requirements per Section 1.3 to be applied for materials that do not include CVN tests.<br>• At time of purchase it should be noted that, unless otherwise specified by the purchaser, Non-destructive testing (NDT) (RT/UT) for pressure containing welds or castings is not mandatory per CSA Z245.15. Both CVN testing at or above -29°C MDMT and NDTare not mandatory per API 6D. |
| | ≥ NPS 4 and < NPS 16 | N/A | CSA Z245.15, Category II; or<br>API 6D | |
| Triple Offset Valves (Liquids Only) | ≥ NPS 6 | TES-VALV-TOV | API 609 | N/A |
| Fittings | ≥ NPS 16 | TES-FITG-LD | CSA Z245.11; or<br>MSS-SP-75 | • Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests.<br>• At time of purchase, it should be considered that per MSS SP-75, CVN testing is required at +20°F for NPS 16 or larger or grade WPHY 65 or greater only unless otherwise specified by the purchaser |
| | ≥ NPS 4 and < NPS 16 | N/A | CSA Z245.11; or<br>MSS-SP-75; or<br>ASME B16.9; or<br>ASTM A420 WPL6 | |

| Commodity | Size | Materials Specification | Industry Standards | Limitations |
|---|---|---|---|---|
| Flanges | ≥ NPS 16 | TES-FLGE-LD | CSA Z245.12; or<br>ASME B16.5; or<br>ASME B16.47 Series A | • Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests.<br>• ASME B16.5 is only applicable up to NPS 24 and ASME B16.47 is only applicable above NPS 24.<br>• Should it be necessary to use ASME flanges, Clause 4.3.12.5 of CSA Z662 requires that the pressure-temperature ratings in accordance with the applicable manufacturing standard shall apply (e.g.,. de-rating at 38°C and higher). |
| | ≥ NPS 4 and < NPS 16 | N/A | CSA Z245.12; or<br>ASME B16.5 | |
| Blind Flanges | ≥ NPS 16 | N/A | CSA Z245.12 or ASME B16.5 or ASME B16.47 Series A | |
| | ≥ NPS 4 and < NPS 16 | N/A | CSA Z245.12 or ASME B16.5 (Material ASTM A105) | |
| Induction Bends | All Sizes | TES-FITG-B1 | ASME 16.49 | N/A |
| Contoured Insert Fittings | All Sizes | TES-FITG-CIF | N/A | N/A |
| End Closures | All Sizes | TES-FITG-EC1 | N/A | N/A |
| Saddles | All Sizes | TES-FITG-SAD | N/A | N/A |
| Pressure Vessels | All Sizes | N/A* | ASME BPVC Section VIII Division I | N/A |

*TransCanada engineering specification(s) from other disciplines than Materials may apply.

# APPENDIX B US AND MEXICO MATERIALS REQUIREMENTS FOR LIQUIDS AND GAS SYSTEMS

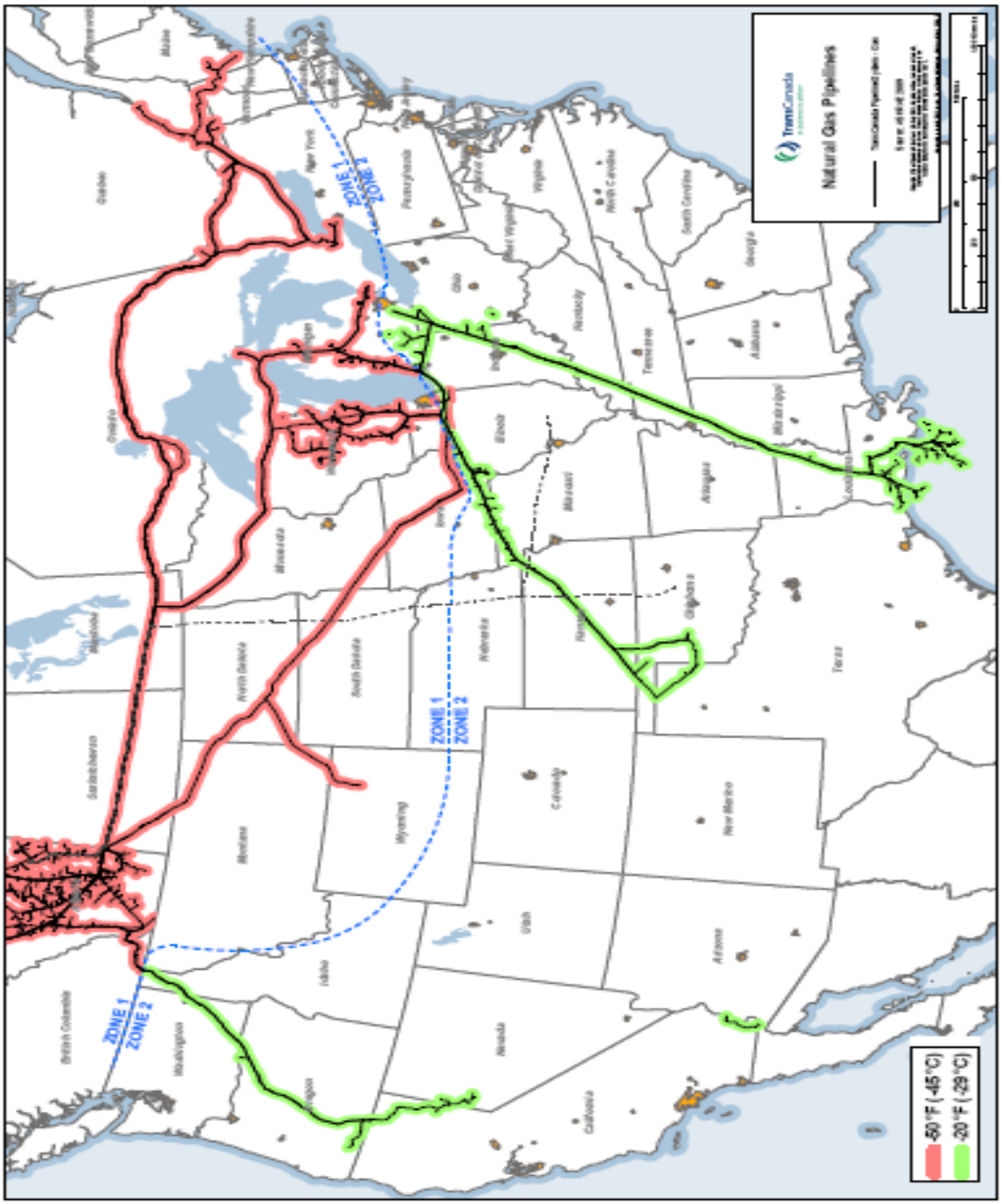
**Appendix Table B-1: US and Mexico Materials Requirements for Liquids and Gas Systems**

| Commodity | Size | Materials Specification | Industry Standards | | Limitations |
|---|---|---|---|---|---|
| | | | Zone 1 (-50°F or < -20°F MDMT) | Zone 2 or Below ground (-20°F or +32°F MDMT) | |
| Pipe | ≥ NPS 16 | TES-PIPE-SAW<br>TES-PIPE-EW | API 5L PSL 2 | API 5L PSL 2 | • Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests.<br>• Above ground pipe for areas with MDMT less than -20°F should be sourced through integrity or station pipe orders directly from pipe mills as pipe with CVN and DWTT below this temperature is difficult to source from distributors. |
| | ≥ NPS 10 and < NPS 16 | TES-PIPE-EW | ASTM A333 or API 5L PSL 2 | ASTM A106 Gr. B or API 5L PSL 2 | |
| | ≥ NPS 4 and < NPS 10 | N/A | ASTM A333 or API 5L PSL 2 | ASTM A106 Gr. B or API 5L PSL 2 | |
| Valves (Ball, Gate, Check, and Plug) | ≥ NPS 16 | TES-VALV-G (Gas)<br>TES-VALV-L (Liquids) | API 6D | API 6D | • Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests.<br>• At time of purchase it should be considered that CVN testing at or above -20°F MDMT and NDT (RT/UT) for pressure containing welds or castings are not required per API 6D unless otherwise specified by the purchaser. |
| | ≥ NPS 4 and < NPS 16 | N/A | API 6D | API 6D | |
| Triple Offset Valves (Liquids Only) | ≥ NPS 4 | TES-VALV-TOV | API 609 | API 609 | N/A |
| Fittings | ≥ NPS 16 | TES-FITG-LD | MSS SP-75 | MSS SP-75 | • Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests.<br>• At time of purchase, it should |
| | ≥ NPS 4 and < NPS 16 | N/A | MSS SP-75 or ASME B16.9 (Material ASTM A420 WPL6) | MSS SP-75 or ASME B16.9 (Material ASTM A234 WPB) | |

| Commodity | Size | Materials Specification | Industry Standards | | Limitations |
|---|---|---|---|---|---|
| | | | Zone 1 (-50°F or < -20°F MDMT) | Zone 2 or Below ground (-20°F or +32°F MDMT) | |
| | | | | | be considered that per MSS SP-75, CVN testing is required at +20°F for NPS 16 or larger or grade WPHY 65 or higher only unless otherwise specified by the purchaser. |
| Flanges | ≥ NPS 16 | TES-FLGE-LD-US | MSS-SP-44; and ASME B16.5 or B16.47 Series A | MSS-SP-44; and ASME B16.5 or B16.47 Series A | • Impact testing requirements per Section 1.3 of this Standard to be applied for materials that do not include CVN tests.<br>• ASME B16.5 is applicable up to NPS 24 and B16.47 is applicable above NPS 24 only and maximum operating pressure for ASME flanges are based on a maximum temperature of 100°F.<br>• Maximum operating pressures for MSS flanges are based on a maximum operating temperature of 250°F |
| | ≥ NPS 4 and < NPS 16 | N/A | MSS SP-44 or ASME B16.5 (Material ASTM A350 LF2) | MSS SP-44 or ASME B16.5 (Material ASTM A105) | |
| Blind Flanges | All Sizes | N/A | MSS SP-44, ASME B16.5 or ASME B16.47 Series A | | |
| Induction Bends | All Sizes | TES-FITG-B1 | ASME 16.49 | | N/A |
| Contoured Insert Fittings | All Sizes | TES-FITG-CIF | N/A | | N/A |
| End Closures | All Sizes | TES-FITG-EC1 | N/A | | N/A |
| Saddles | All Sizes | TES-FITG-SAD | N/A | | N/A |
| Pressure Vessels | All Sizes | N/A* | ASME BPVC Section VIII Division I | | N/A |

*TransCanada engineering specification(s) from other disciplines than Materials may apply.

## APPENDIX C TEMPERATURE ZONE MAP



## APPENDIX D TERMS AND DEFINITIONS

| Terms | Definitions |
|---|---|
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Material |
| CFR | Code of Federal Regulations |
| CSA | Canadian Standards Association |
| DOT | United States Department of Transportation |
| ISO | International Organization for Standardization |
| MSS | Manufacturers Standardization Society |
| NEB | National Energy Board |
| NOM | Norma Oficial Mexicana |
| Regulatory Authority | The national and/or local regulator having jurisdiction over the facility. |
| Welding Procedure | The Welding Procedure Specification, Procedure Qualification Record, and all associated non-destructive and destructive test data |