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December 23, 2020

Ms. Lisa Felice, Executive Secretary
Michigan Public Service Commission
7109 W. Saginaw Hwy.
Lansing, MI 48917

RE: MPSC Docket No. U-20763

Dear Ms. Felice:

On behalf of Enbridge Energy, Limited Partnership's ("Enbridge"), attached for filing in the above-referenced matter, please find the Supplemental Direct Testimony and Exhibits of Aaron Dennis and Certificate of Service of same.

Thank you.

Very truly yours,

Fraser Trebilcock Davis & Dunlap, P.C.

Michael S. Ashton

Digitally signed by Michael S. Ashton
Date: 2020.12.23 15:11:26 -05'00'

Michael S. Ashton

MSA/ab
Attachments
cc: All counsel of record

STATE OF MICHIGAN

BEFORE THE MICHIGAN PUBLIC SERVICE COMMISSION

****

IN RE ENBRIDGE ENERGY, LIMITED PARTNERSHIP **Application for the Authority to Replace and Relocate the Segment of Line 5 Crossing the Straits of Mackinac into a Tunnel Beneath the Straits of Mackinac, if Approval is Required Pursuant to 1929 PA 16; MCL 483.1 *et seq.* and Rule 447 of the Michigan Public Service Commission's Rules of Practice and Procedure, R 792.10447, or the Grant of other Appropriate Relief**	)))))))))))))	**Case No. U-20763**

SUPPLEMENTAL DIRECT TESTIMONY

OF AARON DENNIS

On behalf of the Enbridge Energy, Limited Partnership

December 23, 2020

Q. Would you please state your name, title and business address?

A. My name is Aaron Dennis and my title is Engineer Specialist. I am serving as a witness on behalf of Enbridge Energy, Limited Partnership ("Enbridge"). My business address is 200, 425 1 Street SW, Calgary, AB T2P 3L8, Canada Calgary.

Q. Would you please describe your educational background and work experience?

A. In 2008, I earned by mechanical engineering degree from Lakehead University located in Thunder Bay, Ontario. Upon graduation, I began my career as a pipeline engineer and held various positions including Engineering Manager. In 2013, I joined Enbridge. While with Enbridge, I have held various positions of increasing responsibility. I began as a Pipeline Engineer, and now hold my current position as an Engineering Specialist. I am also registered as a Professional Engineer in the Province of Alberta, Canada. A statement of my qualifications is attached as Schedule 1.

Q. Would you please describe your involvement with the Project?

A. Within Enbridge, I am the lead engineer on the Project and my responsibilities are to oversee the design team for the Great Lakes Tunnel Project including both the design of the replacement pipe segment and the proposed tunnel.

Q. What is the purpose of your supplemental testimony?

A. The Commission Staff requested that Enbridge submit two supplemental exhibits. The purpose of my supplemental testimony is to sponsor those two exhibits. First, Staff asked that Enbridge submit an exhibit to explain how the Great Lakes Tunnel will perform as a location to construct, operate, and maintain the replacement pipe segment, and how the tunnel will act as a secondary containment facility. Second, the Commission Staff requested that Enbridge submit certain of its responses to Staff's discovery requests as an exhibit in this proceeding. The purpose of my testimony is to sponsor the two requested exhibits.

Q. Will you please describe Exhibit A-13?

A. Exhibit A-13 is a Tunnel Design and Construction Report that explains how the Great Lakes Tunnel will perform as a location to construct, operate, and maintain the replacement pipe segment, and how the tunnel will act as a secondary containment facility. As the lead engineer on the Project, I have personal knowledge of the information contained in Exhibit A-13 and it was prepared under my supervision.

Q. Will you please describe Exhibit A-14?

A. Exhibit A-14 is Enbridge's discovery responses to Staff Discovery Requests 2 through 5 and 10 regarding various aspects of the Project, such as the tie-in of the replacement pipe segment, pipe specifications, pipe support within the tunnel, and pipe bends. These discovery responses were earlier served on all parties to this proceeding on September 24, 2020. I have personal knowledge of the information contained in Exhibit A-14.

Q. Does this conclude your supplemental testimony?

A. Yes.

SCHEDULE 1

Aaron Dennis, P.Eng.

Professional Affiliations

Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Education

Bachelor of Mechanical Engineering, Lakehead University (2008)

Diploma – Mechanical Engineering Technology, Lakehead University (2005)

Professional History

Enbridge Inc.: Engineering Lead (Mar 2019 – Present)

Enbridge Inc.: Sr. Pipeline Engineer (Nov 2013 – Mar 2019)

IMV Projects: Engineering Manager Pipeline Projects (May 2013 – Nov 2013)

IMV Projects: Pipeline Project Engineer (2008 – 2013)

Peter Kiewit Sons' Inc. (BC): Field Engineering Intern (May 2007 – Sept 2007)

Ontario Power Generation (ON): Project Engineering Intern (May 2006 – May 2007)

Key Project Experience

Enbridge Line 5 Relocation and Tunnel Project   March 2019 to present

Engineering Lead for the project consisting of an extensive geotechnical exploration program both in water and on land. Acting as the owner representative for all engineering related activities for the project.

Enbridge GTA Project Nov 2013 to Feb 2015

Sr. Pipeline Engineer Acted as client representative in an engineering consultants home office providing direction on project deliverables. Provided technical advice and expertise related to pipeline engineering, construction and procurement activities.
Managing project to Providing technical advice and expertise related to pipeline design, execution, and procurement activities.

Cenovus – Foster Creek 2013 Pipeline Development

Pipeline Project Engineer for Detailed engineering on an above ground thermal pipeline project consisting of approximately 7km of new pipelines (Steam, Emulsion, Casing Gas, and Fuel Gas) to service six new SAGD production pads along with future development.

Cenovus – Christina Lake 2014 Pipeline Development

Pipeline Project Engineer for FEED and detailed engineering on an above ground thermal pipeline project consisting of approximately 4km of new pipelines (Steam, Emulsion, Casing Gas, and Fuel Gas) to service two new SAGD production pads along with future development.

Cenovus – Christina Lake 2012 Pipeline Development

Pipeline Project Engineer for FEED and detailed engineering for an above ground thermal pipeline project consisting of approximately a 2km NPS 24 steam pipeline twinning and pipeline laterals servicing two new SAGD production pads.

Cenovus – Christina Lake 2012 Interconnecting Pipelines

Pipeline Project Engineer for FEED and detailed engineering on pipeline project which consisted of both above ground and below ground sales oil and diluent lines. This was a brown field project with several tie points within the Christina Lake CPF.

Cenovus – Christina Lake 2010/12 Brackish Water

Pipeline project engineer for detailed engineering and construction support for BW1, CW2, and CW3 brackish source water pads and related pipeline.

Cenovus – Christina Lake 2010 Disposal Water Project

Pipeline project engineer for detailed engineering and construction support for the addition of three new disposal wells and related manifold building on RD1 pad.

Cenovus – Christina Lake 2010 Pipeline Development

Pipeline engineer for detailed design and construction support of an above ground thermal pipeline project consisting of 7.5km of new pipelines servicing 5 new SAGD production pads.

Cenovus – Foster Creek 2010 Pipeline Development

Pipeline engineer for detailed design and construction support of an above ground thermal pipeline project consisting of 6km of new pipelines servicing 4 new SAGD production pads.

CNRL – Primrose North Pipeline Expansion (2008)

Pipeline engineer for detailed design and construction support of an above ground thermal pipeline project consisting of 8km of new pipelines servicing 5 new SAGD production pads.

Relevant Work Experience

Enbridge Inc., Calgary Nov. 2013 – Present

- Provided technical oversight of new specification development and updates to existing pipeline construction specifications.
- Fulfilled role of trenchless crossings subject matter expert for HDD, Direct Pipe and bored crossings
- Provided guidance on routing and scoping of new pipeline projects.
- Provided ongoing support to field engineering staff for general pipeline construction issues.
- Contributed to the development of CEPA guidelines of construction best practices to prevent dents and ovalities.

- Contributed to the development of PRCI project to develop tool to predict pipeline stresses while lowering-in to the ditch.
- Provided technical expertise in post-incident investigation regarding third party construction related damage.
- Provided technical expertise in response to incident related to geotechnical slope failures and generation of alternate solutions to crossings.

IMV Projects, Calgary Jan. 2013- Nov. 2013
Engineering Manager – Pipeline Projects

- Providing technical guidance for all disciplines.
- Providing mentorship to less experienced engineers.
- Developing procedures and job instructions
- Lead team and discipline meetings.
- Responsible for approving all studies, reports and CWPs.
- Assisting with resource planning for the pipeline department.

IMV Projects, Calgary June 2008 – Jan. 2013
Pipeline Project Engineer

- Coordinated design and construction activities for several large pipeline projects (~$50M)
- Provided manhour and material estimates for various pipeline projects.
- Prepared supporting documentation including technical reports and license application packages (ABSA/ERCB).
- Maintained a working relationship with the client and field operations to ensure smooth design and construction phases.
- Prepared monthly engineering progress reports.
- Reviewed structural, and process drawings.
- Approving and stamping of pipeline drawings.
- Managing and delegating work within the project team
- Performed many procurement activities including technical bid evaluations.

EXHIBIT A-13

Exhibit A-13

Tunnel Design and Construction Report for the Straits Line 5 Replacement Segment

December 23, 2020

Prepared by:

Enbridge Energy, Limited Partnership

EXHIBIT A-13

Table of Contents

EXHIBIT A-13

Abbreviations

CFM	Cubic feet per minute
CSPE	Confined Space Permit Entry
Enbridge	Enbridge Energy, Limited Partnership
Gpd	Gallons Per Day
HVAC	Heating, ventilation, and air conditioning
ILI	Inline Inspection
kV	Kilovolts
LEL	Lower Explosion Limit
MCS	Mechanical Control System
MEP	Mechanical, Electrical and Plumbing
MPSC	Michigan Public Service Commission
MS	Mackinaw Station
MSCA	Mackinac Straits Corridor Authority
MVA	Mega Volt-Amp
NS	North Straits Station
NSS	North Straits Shaft
OSHA	Occupational Safety and Health Administration
PCTL	Precast Concrete Tunnel Lining
PLC	Programmable Logic Controllers
Project	Straits Line 5 Replacement Segment
SME	Subject Matter Expert
Straits	Straits of Mackinac

EXHIBIT A-13

State	State of Michigan
ST	Straits Tunnel
TBM	Tunnel Boring Machine
TDCR	Tunnel Design and Construction Report
TS	Tunnel System
TSV	Tunnel Support Vehicle
V	Volt

EXHIBIT A-13

Tunnel Design and Construction Report
Michigan PSC Case No. U-20763

1 INTRODUCTION

This Tunnel Design and Construction Report ("TDCR") was prepared in support of an application filed with the Michigan Public Service Commission ("MPSC") pursuant to the Michigan Crude Oil and Petroleum Act 16 of 1929 (1929 PA 16; MCL 483.1 et seq., as amended) and Rule 447 of the MPSC's Rules of Practice and Procedure (R 792.10447) to replace the Line 5 Dual Pipelines' crossing of the Straits of Mackinac ("Straits") with a replacement pipe segment that is to be located in a tunnel constructed beneath the lakebed of the Straits. This TDCR describes how the tunnel will perform as a location to construct, maintain, and operate the replacement pipe segment within the tunnel and how it will act as a secondary containment facility ("Project"). Pursuant to the Tunnel Agreement, the Mackinac Straits Corridor Authority ("MSCA") and Enbridge will jointly develop the Project Specifications related to design and construction of the tunnel.

Locating the replacement pipe segment within the tunnel eliminates the possibility of any release into the Great Lakes that may result from the operation of the existing Line 5 Dual Pipelines. The tunnel, located underground at a depth of approximately 60 feet to 250 feet beneath the lakebed, creates a controlled, contained environment to more safely operate and maintain the replacement pipe segment and protect surrounding resources from release.

1.2 Project Description

1.2.1 General Description

The Project scope consists of a proposal to install a single, 30-inch diameter pipe segment to be located within a concrete-lined tunnel which will have an inside diameter of approximately 21-feet and be approximately four-miles long located beneath the lakebed of the Straits. The purpose of the Project is to replace the existing Line 5 Dual Pipelines crossing of the Straits with a replacement pipe segment that is located within the tunnel.

The tunnel would be constructed using a tunnel boring machine ("TBM"). A Precast Concrete Tunnel Lining ("PCTL") would be installed as the tunnel is constructed, and the annular space outside the tunnel's concrete lining would be filled with low-permeability grout. Refer to Attachment 1, figure 5, for the Tunnel Drawings.

Construction of the tunnel will require a launch structure on the south side of Straits and a receiving shaft on the north side. Both the south side and north side will house permanent access structures for the tunnel. Upon completion, the single, 30-

inch diameter replacement pipe segment located within the tunnel will be tied to the existing and previously approved Line 5 at both sides of the Straits.

The Project will allow for the discontinuation of service on the existing Line 5 Dual Pipelines upon placing the replacement pipe segment into service within the tunnel.

1.3 Facility Outline

The Facilities for the single 30-inch diameter pipe segment are divided into three areas plus tunnel systems to support the operations and maintenance:

1. Mackinaw Station ("MS")
2. Straits Tunnel ("ST")
3. North Straits Station ("NS")
4. Tunnel Systems ("TS")

2 SCOPE AND DESIGN OF FACILITIES

Enbridge has developed specifications to outline the technical design requirements of the Facilities. The specifications ensure the design and construction is in accordance with prevailing, state of the practice tunnel standards and specifications for a tunnel design life of no less than 99 years. The design life of the Facilities, including the tunnel, can effectively be indefinite with proper maintenance and inspection.

2.1 Mackinaw Station

In the permanent condition a shaft will provide a route for the pipeline to return to grade and will house vertical risers for mechanical, electrical and plumbing ("MEP") equipment for tunnel operation. Access to the tunnel will facilitate maintenance access to the ST.

2.2 Straits Tunnel

The route of the tunnel has been designed to remain within the bedrock and will cross three geologic formations - the Bois Blanc, St. Ignace and Pointe Aux Chenes. The tunnel will be excavated using a custom TBM designed specifically for the geologic conditions found during the field investigations performed.

The design of the tunnel structure will achieve the following key objectives:

1. The tunnel structure design life equal to 99 years.

2. Provision of sufficient space for the internal elements to support the installation, operation and maintenance of the pipeline, and to allow the same for other third-party utilities.
3. Designed in accordance with the specified design codes and standards.
4. Minimization of potential impacts to existing structures and utilities.
5. Designed to meet the specified water tightness requirements.

2.3 North Straits Station

The NS is required to facilitate TBM retrieval during construction, provide a permanent route for the pipeline to return to grade, and to house MEP equipment for tunnel operation.

2.4 Tunnel Systems

The permanent tunnel systems will be comprised of:

- Communication systems to facilitate maintenance activities and emergency response.
- Electrical system to provide power to the sump pump, ventilation fans and other equipment.
- Tunnel ventilation fans and systems at the MS and NS.
- Tunnel dewatering sump pumps at the low point in the tunnel.
- Gas and liquid hydrocarbon leak detection.
- Air lock doors at the entrance of the tunnel - on both ends - to provide an additional measure of safety and fire protection (doors limit the oxygen supply in the event of a fire).

Detailed descriptions of the ventilation, sump, leak and gas detection systems are described below in Section 3, Pipeline Operation and Maintenance. Also, refer to Figures 1-3 of the Tunnel Drawings in Attachment 1 and the Tunnel Systems Diagram in Attachment 2.

2.4.1 Communication Systems

The following communication systems will be provided within the tunnel:

- Tunnel emergency telephone system.
- Tunnel radio system (with emergency services channels). The tunnel radio communications will be supported by way of a distributed antenna system.
  - A distributed antenna communication system consists of a cable run along tunnels which emits and receives radio waves, functioning as an extended antenna. The cable has gaps or slots in its outer conductor to

allow the radio signal to emit into or out of the cable along its entire length. These cable feeders were originally used in underground mines. Today they are often used in skyscrapers, tunnels, ships and planes to extend mobile coverage.

2.4.2 Electrical Systems

The tunnel will generally be unpowered except for power to the sumps, communications and the leak detection system within the tunnel. Lighting will not be provided within the tunnel; the tunnel service vehicle ("TSV") will be equipped with lights and portable lighting can be brought into the tunnel as needed. Instrumentation provided within the tunnel shall meet National Fire Protection Association, National Electric Code requirements for Class 1, Division 2 locations.

Class I, Division 2 are areas where ignitable concentrations of flammable gases, vapors or liquids are not likely to exist under normal operating conditions. In this area the gas, vapor or liquids are contained within closed containers (e.g., the pipeline) and would only be present under abnormal conditions, for example in the unlikely event of a leak. Additional details on the requirements associated with a Class 1, Division 2 categorization can be found below in Section 3.4 Leak & Gas Detection and Isolation Philosophy.

The NS will receive power supply from a dedicated Utility Company transformer located adjacent to the fan plant. The MS power supply will be derived from the existing Utility Company 7.5 Mega Volt-Amp ("MVA") 4360V transformer supply that feeds the existing MS pump station.

An emergency generator will also be installed adjacent to the transformers to ensure a redundant power supply.

2.5 Third-Party Utilities

Provisions have been made to accommodate the future installation for third-party electric and telecommunication utilities:

- **Electrical Power Circuits:** the tunnel and portal Facilities will accommodate up to two (2) 230kV circuits comprising of 3No 1000 kilo-circular mils phase conductors, a ground and a communications cable.
- **Telecommunications**: space in tunnel for a thirty-six-inch (36-inch) cable tray.

Third-party utilities shall seek access to utilize the tunnel in accordance with the procedures established in the Tunnel Agreement executed by the Mackinac Straits Corridor Authority and Enbridge. Third-party utilities shall be responsible for the means and methods of construction including but not limited to provisions to prevent any damage to the pipeline/facilities or other existing third-party utilities including cable installation, operational fault conditions and any electric magnetic field mitigation required to prevent induced currents.

2.6 Tunnel Construction

The tunnel would be constructed using a TBM and will be launched from the Mackinaw Station Portal ("MSP"). TBMs are technically sophisticated pieces of equipment used to excavate tunnels in all types of ground conditions. TBMs can be configured so that they are suited to conditions with high groundwater pressure, which is a condition expected for this Project.

The TBM is made of three sections—rotating cutterhead, shield, and trailing gear—and will be approximately 500 ft. long. Disc cutters on the cutterhead break small rock chips from the tunnel face by rotating and applying high contact pressure. The shield skin provides for the safety of personnel and the TBM. The shield of the TBM prevents water, soil and rock from entering the tunnel during construction. The trailing gear contains the TBM's electrical, mechanical, guidance systems and additional support equipment. Hydraulic cylinders located in the trailing gear propel the TBM forward a few feet at a time.

As the cutterhead slowly rotates the excavated material - a slurry and rock mixture - is transported to the rear of the machine where it is pumped out of the tunnel via a slurry transport pipe. The excavated material is separated from the slurry at an on-site slurry treatment plant and moved off-site and disposed of in a manner consistent with applicable environmental regulations.

The geology is not known to have hazardous gas. Nevertheless, tunnel ventilation will be provided throughout the tunneling process. Likewise, gas detection and monitoring equipment will also be used during construction. Further, the tunnel lining has a double gasket, reducing the infiltration of gases as well as water. (See, Sections 3.4 and 3.5 below for a detailed discussion of ventilation and gas detection during the operation of the tunnel.)

The project specifications require that the TBM be equipped with a gas detection system. The gas detection system will monitor for methane, and also for other combustible and toxic gases, carbon dioxide, and oxygen. The data will be continuously monitored as part of the Tunnel Monitoring and Documentation system.

EXHIBIT A-13

If concentrations exceeding certain limits are detected in the workspace, the monitoring system will activate alarms, and equipment interlocks will shut down electrical power, except for life safety support systems such as emergency ventilation, emergency lighting.

During interventions for maintenance at the face, the excavation chamber will be purged of any hazardous gases, prior to worker entry. Workers in the excavation chamber will have portable gas detection monitors to continuously monitor the environment in the chamber during interventions. Additionally, a feed-through to the excavation chamber will be provided for fire suppression.

2.7 Tunnel Diameter and Lining

The tunnel will have an approximately 21-foot inside diameter, will be approximately four-miles long, and will link the new MSP on the southside of the Straits to the North Straits Shaft (“NSS”). The excavated tunnel will be lined with a PCTL. Refer to Figures 4-5 of the Tunnel Drawings in Attachment 1.

2.7.1 Space Proofing

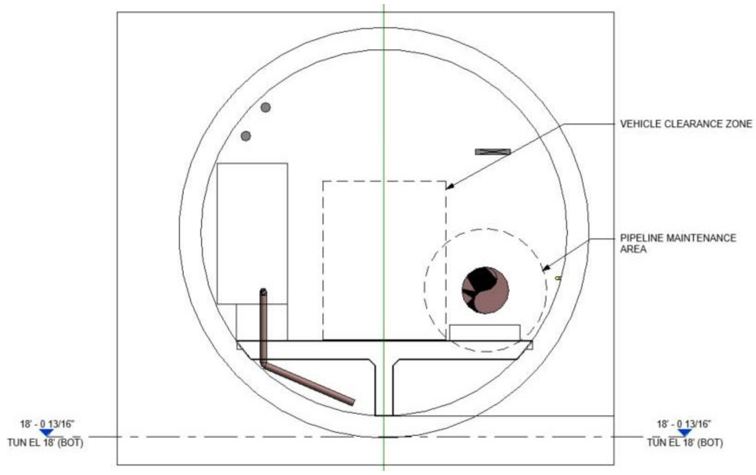
The tunnel will be open and accessible to allow for pipeline installation, pipeline maintenance, and inclusion of other third-party utilities, as noted in section 2.5. The pipeline is mounted on pipe supports with approximately 30 inches of space around the pipeline to facilitate inspection and maintenances activities. The tunnel will also allow space for the mechanical and electrical equipment, ventilation equipment, and inspection and maintenance by a TSV.

The image shows how the tunnel has been designed to accommodate maintenance and inspection activities.

EXHIBIT A-13

Tunnel Design and Construction Report
Michigan PSC Case No. U-20763

Figure 1: Tunnel Space Proofing View



2.7.2 Tunnel Durability

The structural design of the tunnel ensures that it is designed to resist all applied loads without failure during its intended life, including, permanent loads, live loads, external water pressure loads, internal air pressure loads, earthquake effects, fire loads, and construction loads.

The tunnel durability has been evaluated to verify that it is expected to meet or exceed its required design life. This evaluation has been performed using current engineering practice standards for the evaluation of corrosion of reinforcement steel and degradation of concrete, considering the specific conditions expected in the tunnel environment. Factors considered include chemically induced degradation from the ground or groundwater, freeze-thaw, and chemical reactions in concrete based on humidity conditions and aggregate characteristics. The design requirements for durable materials have been incorporated in the construction specifications, and construction testing and inspection will be performed to verify that materials and installation meet specification requirements.

To verify tunnel integrity, a periodic in-service inspection program will be implemented. These inspections will verify the tunnel is performing as anticipated. Similar to how bridges and transportation tunnels are inspected, inspection protocols will be developed and implemented for the tunnel to ensure the on-going operability and integrity of the structure.

2.7.3 Precast Concrete Tunnel Lining

The tunnel will be lined with a PCTL. The PCTL is installed in segments from the tail section of the TBM shield as the boring progresses, enabling continuous tunneling and safe working conditions. The PCTL is composed of six segments and incorporates high-strength rubber gaskets to limit water leakage. Refer to Figures 4 and 5 within Attachment 1 for the PCTL drawings.

The concrete lining of the tunnel will provide secondary containment, preventing any pipeline release of liquids from the tunnel into the Straits. In addition, the tunnel lining has been designed to be resilient against a hydrocarbon fire and any anticipated fire exposure condition. As described above, the concrete lining system includes high strength, high quality pre-cast concrete elements and durable, petroleum-resistant, high pressure resistant gaskets.

Additionally, the tunnel will be constructed well below the lakebed of the Straits. Finally, existing groundwater pressure in the soil and rock pores around the tunnel further prevents any leaked liquids within the tunnel from migrating into the lakebed or Straits, since the pressure outside the tunnel will far exceed any leaked liquids pressure within the tunnel.

2.8 Pipeline Installation within the Tunnel

The replacement pipe segment will be designed, installed, operated, and maintained in accord with federal pipeline safety regulations, specifically the Pipeline and Hazardous Materials Safety Administration ("PHMSA") pipeline safety regulations Parts 194 and 195 (49 Code of Federal Regulations "CFR" Parts 194 and 195). This also includes hydrostatic testing of the replacement pipe segment per Subpart E of Part 195. The pipe specifications for the replacement pipe segment will meet the requirements imposed by PHMSA.

The design, installation, and testing of the pipeline will incorporate the unique characteristics of the project including designing the pipeline expansion loops to accommodate the anticipated thermal expansion during operations as well as the stresses and growth anticipated during hydrostatic testing.

The replacement pipe segment is proposed to be installed by welding the pipe joints at the south side near the existing MS and incrementally advancing the welded pipe into the tunnel by a combination of pushing and pulling methods.

The pipeline will be installed on permanent rollers on pipe supports mounted to the PCTL. The rollers will aid pipeline installation and allow for pipe expansion during operations.

For a detailed description of the pipeline design parameters refer to Exhibit A-14, MPSC Staff Information Request Number 3.

EXHIBIT A-13

Tunnel Design and Construction Report
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3 Pipeline Operation and Maintenance

As noted above, the replacement pipe segment will be operated and maintained in accordance with safety requirements established by PHMSA under 49 C.F.R. Part 195. The design life of the replacement pipe segment will be managed through operational and maintenance safety measures, such as corrosion protection, pipe coating, and inline inspection ("ILI"). Cathodic protection is not being applied to the pipeline in the tunnel as the pipeline is supported above grade on pipe supports in atmospheric conditions. The pipeline is externally coated to protect it from corrosion. Also, to allow for external corrosion inspection and maintenance activities of the pipe, the supports are designed to be removable.

3.1 Regular Inspection of the Pipeline

Prevention is a key component of Enbridge's safety program. Enbridge's proactive inspection program allows it to monitor the fitness of the pipelines from both the inside and the outside.

3.1.1 Internal inspections

Enbridge will use ILI tools on a regular basis, to make thorough evaluations of the replacement pipe segment to identify any features that could impact the safety or integrity of the segment.

These ILI tools use imaging technology, with a level of detail similar to that of MRIs, ultrasound and X-ray technologies in the medical industry. ILI tools alert Enbridge to any issues in the pipeline that may require immediate attention, further analysis, repair, or maintenance. Data collected from those scans is analyzed by specialized computer programs and expert engineers and is continually compared to get a full picture of what's happening inside the pipeline.

3.1.2 External inspections

Enbridge will also make regular visual inspections of the replacement pipe segment. These external inspections provide a thorough, detailed look at the exterior of the pipe and its immediate environment.

3.2 Pipe Support and Anchors

The pipeline will be supported on pipe supports throughout the tunnel. The support types will vary between vertical supports and guide supports based at set intervals along the tunnel and mounted off the PCTL. The pipeline will be anchored at approximately the mid-point of the tunnel to allow for any thermal expansion to be directed to each end of the tunnel.

The pipe supports will be designed to allow for the pipeline to be installed within close tolerances along the designed pipeline alignment, accounting for the tunnel alignment tolerance. Pipe support structures are designed for 99-year life, are designed for replacement if warranted, and will be designed for easy replacement.

3.3 Tunnel and Pipeline Operations and Maintenance

3.3.1 Normal Conditions

Under normal conditions the tunnel will be unoccupied and ventilation systems in the tunnel will be off. The only systems operational within the tunnel will be the communications systems, hydrocarbon (gas and fluid) detection, the mid-tunnel substations and the tunnel sump pump.

3.3.2 Maintenance and Inspection Conditions

The tunnel will be normally unoccupied except during maintenance and inspection activities. Therefore, the tunnel has been designated as a Confined Space Permit Entry ("CSPE") and existing Enbridge standard operating procedures will be refined to be specific to confined space tunnel entry.

Under maintenance conditions the ventilation system will operate as follows:

1. Prior to personnel entry, the ventilation system will purge the tunnel until the air quality within the tunnel becomes acceptable.

2. Once purged, the tunnel ventilation system will operate to maintain a safe working atmosphere.

The tunnel communications systems will provide both radio and wired communication between the tunnel and the above ground control room. The radio system will be provided via a distributed antenna communication system. The fixed communication systems will be provided via mine telephones located approximately 800 ft. throughout the tunnel. These systems will connect to the local control room at MS.

The sump pumps and substations mode of operations will not change from normal conditions unless maintenance on these particular pieces of equipment is being carried out. During the summer months, there is a likelihood of condensation occurring in the tunnel due to the humidity of the outside air which will cause the pumps to discharge on a 24- to 36-hour cycle during prolonged maintenance and inspection events.

3.4 Leak & Gas Detection

The pipeline leak detection is comprised of two layers. The first layer is computation pipeline monitoring where the Enbridge Control Center constantly monitoring pressure, temperature, flow and other key data to quickly identify and respond to unexpected changes. The second layer is an external leak detection system installed within the tunnel and is comprised of gas monitors and liquid hydrocarbon detection systems.

To mitigate the risk of a fire/explosion, multiple points of gas detection will be installed. Specifically, there will be three detectors installed at nine locations within the tunnel and near and at the tunnel entrances.

Hydrocarbon leak detection will be installed at the MS and NS shaft sumps and tunnel sump. These devices will communicate directly with the Enbridge Control Center, where they will be monitored 24/7/365 by a dedicated team of specially trained Enbridge staff members, in accordance with PHMSA control room management requirements under 49 C.F.R. Part 195. A strobe light shall be mounted on the outside wall near the doorway, clearly visible from a distance. The strobe shall be activated when gas is detected.

In addition, as described in Section 2.4.2, all equipment installed in the tunnel must comply with Class I, Division 2 locations. This classification requires that all equipment be rated for installation within the space and that ventilation be provided so that the Lower Explosive Limit ("LEL") of the gases is not exceeded under normal conditions, thereby eliminating an ignition source and preventing a fire/explosion from occurring.

The minimum concentration of a particular combustible gas or vapor necessary to support its combustion in air is defined as the LEL for that gas. Below this level, the mixture is too "lean" to burn.

3.5 Ventilation

The permanent Facilities consist of two fan plant buildings sitting on top of tunnel access shafts on both sides of the Straits and connected together by the tunnel.

The tunnel ventilation supply ducts extend downward through the access shafts and pass through two air lock doors. The air lock doors prevent air flow through the tunnel, starves a fire of oxygen if one occurs, and allows personnel to transition from tunnel pressure to outside pressure.

The tunnel will be normally unoccupied except for maintenance and inspection. Therefore, the tunnel will be treated as a permit access confided space with respect to access and safety provisions. In its maintenance mode (ventilated and occupied), the ventilation system has been designed to keep air quality at acceptable levels.

An emergency generator will be provided should the fan plant need to run during a utility outage.

3.6 Tunnel Sump Pump

Tunnel drainage will be via a sump pump at the low point of the tunnel to collect ground water infiltration and condensation when outside air is introduced above the dew point. Two pumps will be provided at the sump. Each pump will be controlled independently through the Supervisory Control and Data Acquisition (“SCADA”) systems and each will have independent power supplies to prevent a power failure stopping pump discharge. All tunnel inflow water will be pumped via the tunnel drainage pipe to an oil water separator at the MS before discharge through the outfall to the Straits or disposal.

The tunnel sump pump will operate intermittently based on the water infiltration rate through the tunnel liner. Based on the sump size, Enbridge estimates that the pumps will operate approximately once every six days based on a maximum allowable infiltration rate of 7,000 gallon per day (“gpd”).

3.7 Tunnel Service Vehicles

The TSV is a custom built, electrically powered vehicle designed to provide regular access, inspection and maintenance of the pipeline and tunnel for the Project. The vehicle has an electric drive train and is powered by battery packs mounted on the vehicle. Two separate passenger cabs allow for bi-directional drive capabilities and capacity for four people. The confined space in the tunnel prevents vehicle turning, making a bi-directional drive necessary.

3.8 Emergency

Emergency conditions are defined either by a product leak and/or a fire event in the tunnel. With respect to operation of the replacement pipe segment, Enbridge will comply with all emergency response requirements established by PHMSA under 49 C.F.R. Part 194. Enbridge will amend as appropriate, and seek PHMSA approval of, its emergency response plan(s) to address a potential product leak from the replacement pipe segment.

3.8.1 Product Leak

Emergency preparedness and response requires a systematic approach to ensure that all hazards are anticipated so that an emergency response is rapid, effective and protective of workers, the public and the environment. Liquid hydrocarbon leak detection is being provided at the tunnel low point within the drainage sump. In the event of a leak, the leak detection system will be activated to provide an audible and visual alarm to the Enbridge Control Center.

- In the event of a product leak, Enbridge will implement its PHMSA-approved emergency response plan(s) applicable to the replacement pipe segment to timely and efficiently respond to and mitigate the consequences of a product leak from the replacement pipe segment within the tunnel. Enbridge, its contractors, and emergency responders work together to evaluate and respond to a pipeline release. For example, as part of any response: Enbridge personnel may shut down or isolate sections of the pipeline or facility.
- Local emergency responders may oversee public safety measures like securing the scene.
- Enbridge will work with applicable agencies to remediate any impacts caused by a release.

3.8.2 Fire Response

In the event of a fire while the maintenance personnel are in the tunnel, the ventilation system operating mode will be modified based on the location of the fire and the direction of air flow such that the personnel can always be evacuated into the direction of the supplied fresh air. This will require manual control of the fan plant based on information supplied by the personnel about the location of the fire and the egress direction they choose. Allowing persons to evacuate safely and leaving the communications system on-line to facilitate any emergency messages from the personnel in the tunnel.

Once personnel are safely evacuated a decision will need to be made by the local control center whether to secure the air lock and switch-off the ventilation system to starve the fire of oxygen or to let it continue to burn.

The risk of a fire within the tunnel if the tunnel is unoccupied by maintenance personnel is negligible because there would be no ignition source present as everything in the tunnel is meeting requirements for Class 1, Division 2.

EXHIBIT A-13

Tunnel Design and Construction Report
Michigan PSC Case No. U-20763

4 CONTROL SYSTEM

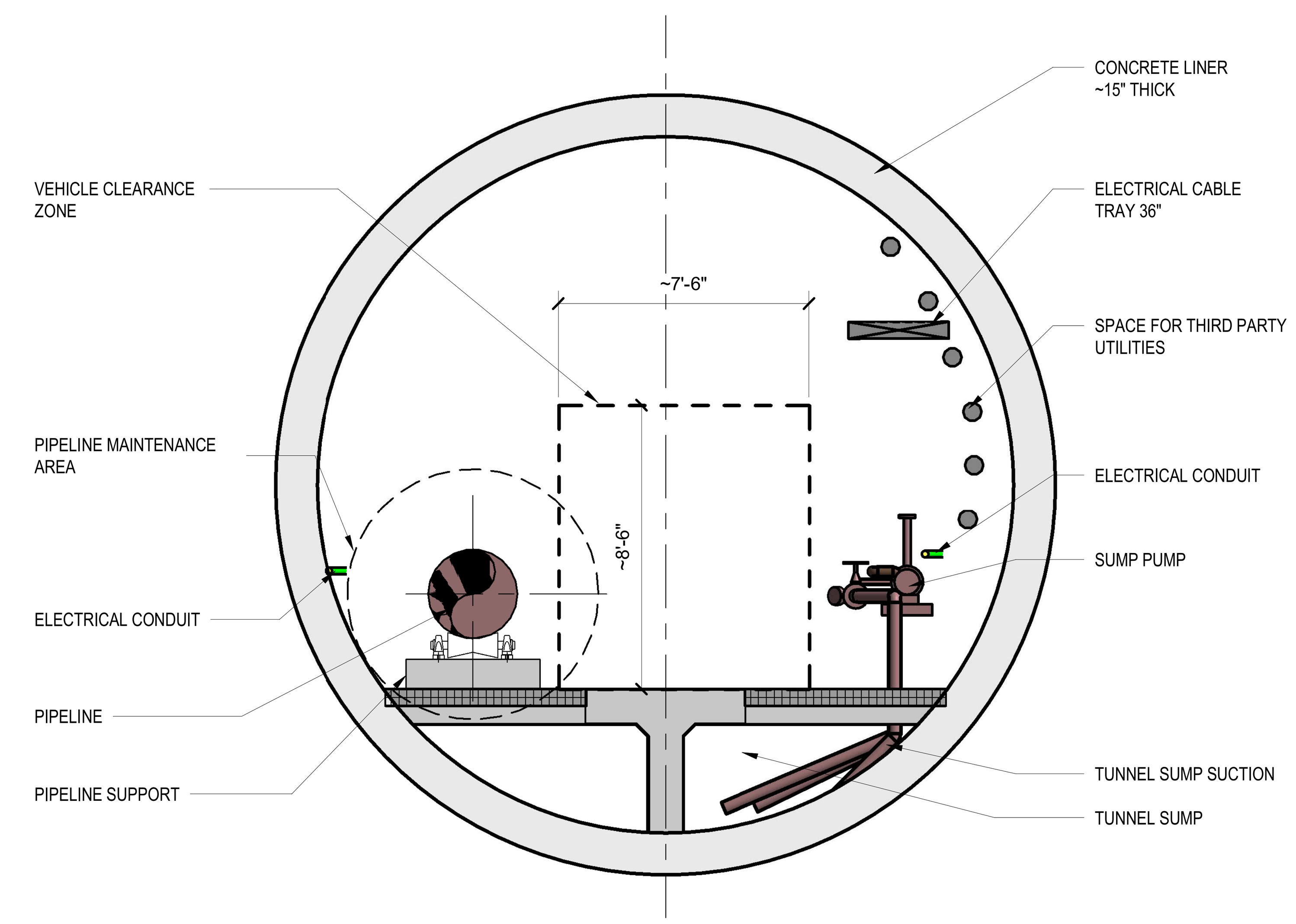
The Mechanical Control System ("MCS") SCADA provides the means for both local and remote control monitoring of the tunnel ventilation fans, dampers, tunnel sump pumps, gas and leak detection system, oil water separator system and miscellaneous heating, ventilation, and air conditioning ("HVAC") related equipment. The system comprises of hot/standby programmable logic controllers ("PLC"), hot/standby servers, operator workstations and graphical user interfaces, instrumentation, as well as control and monitoring software. The system PLC control cabinets, three in total, are to be located within the tunnel sump area, NSS and MSP. Communication between the system components will be via a fiber optic cabling network comprised of fiber optic patch panels and network switches. The MCS shall be connected to the Enbridge network for remote access by operations.

5 CONCLUSION

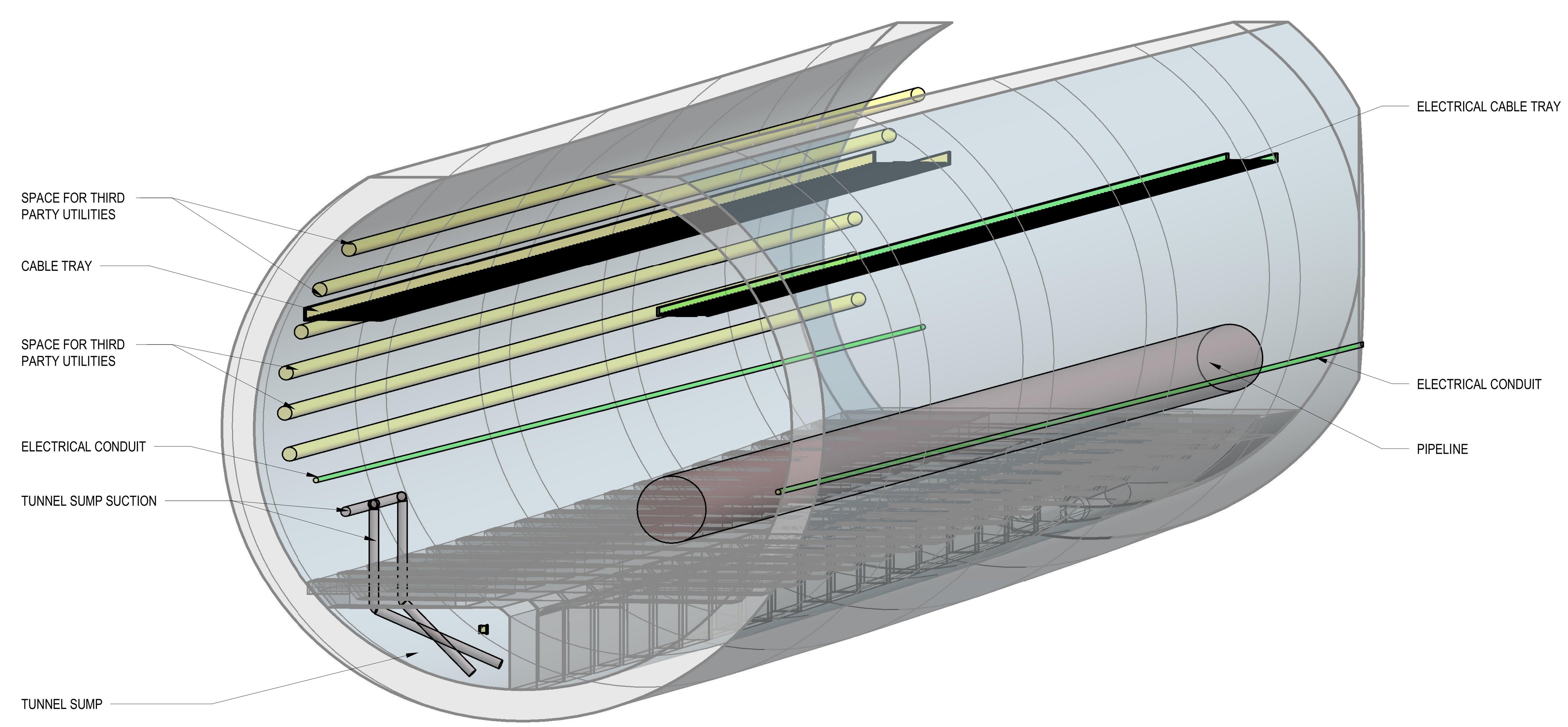
As discussed throughout this TDCR, the tunnel will perform as an efficient and effective location to construct, maintain and operate the replacement pipe segment. The replacement pipe segment will be maintained and operated in accordance with applicable federal regulations.

ATTACHMENT

1



1 Tunnel Cross Section @ Sump Pump Location
1/4" = 1'-0"



2 Tunnel @ Sump 3D View
NTS

STAMP

ORIGINATING COMPANY

ARUP

ARUP TEXAS INC
10370 RICHMOND AVENUE, SUITE 475
HOUSTON, TX 77042

REF	DRAWING NUMBER	DRAWING TITLE

REFERENCE DRAWINGS

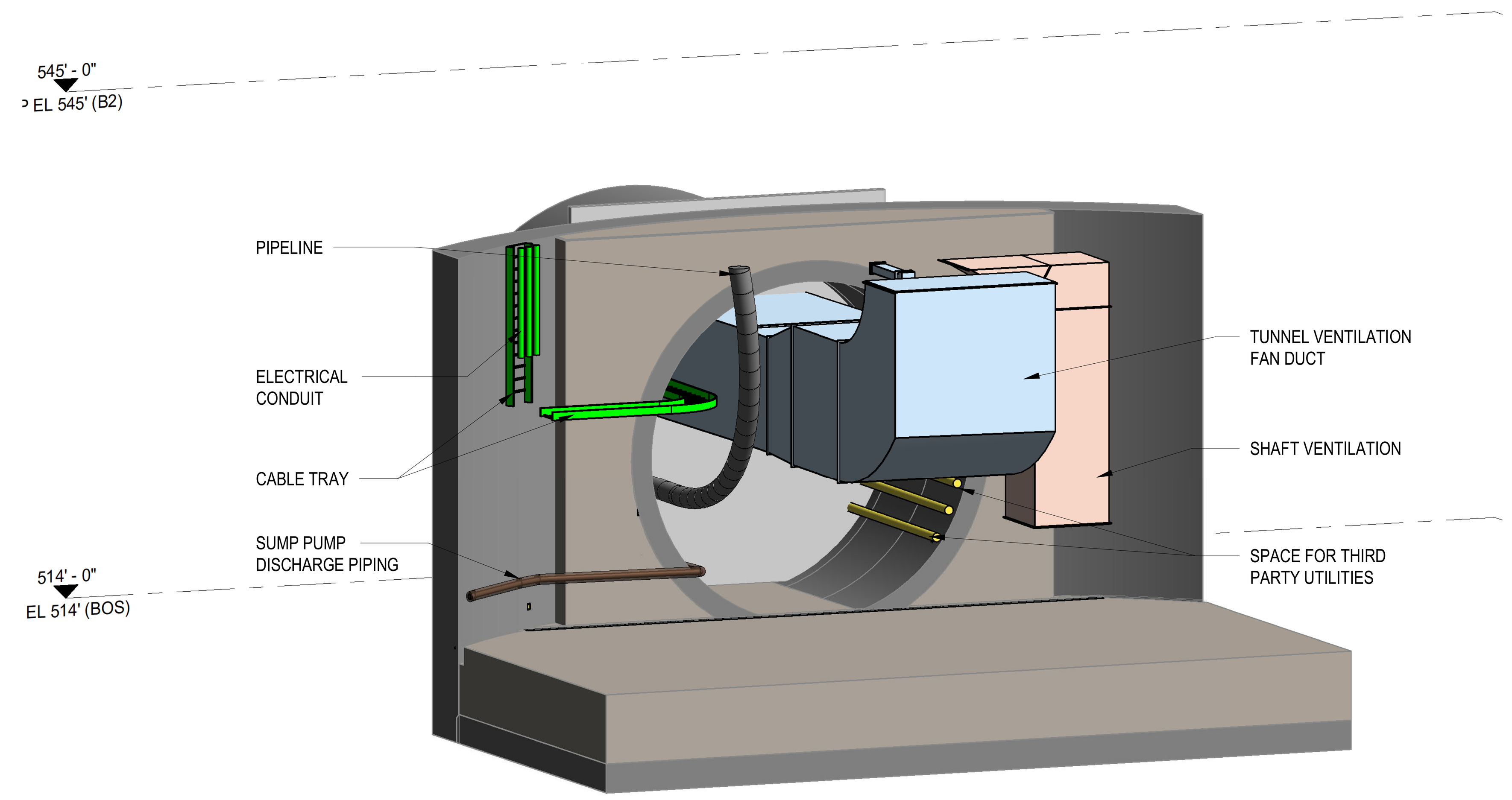
REV NO	REVISION DESCRIPTION	DATE BY	CHK	APPR

ENBRIDGE ARUP

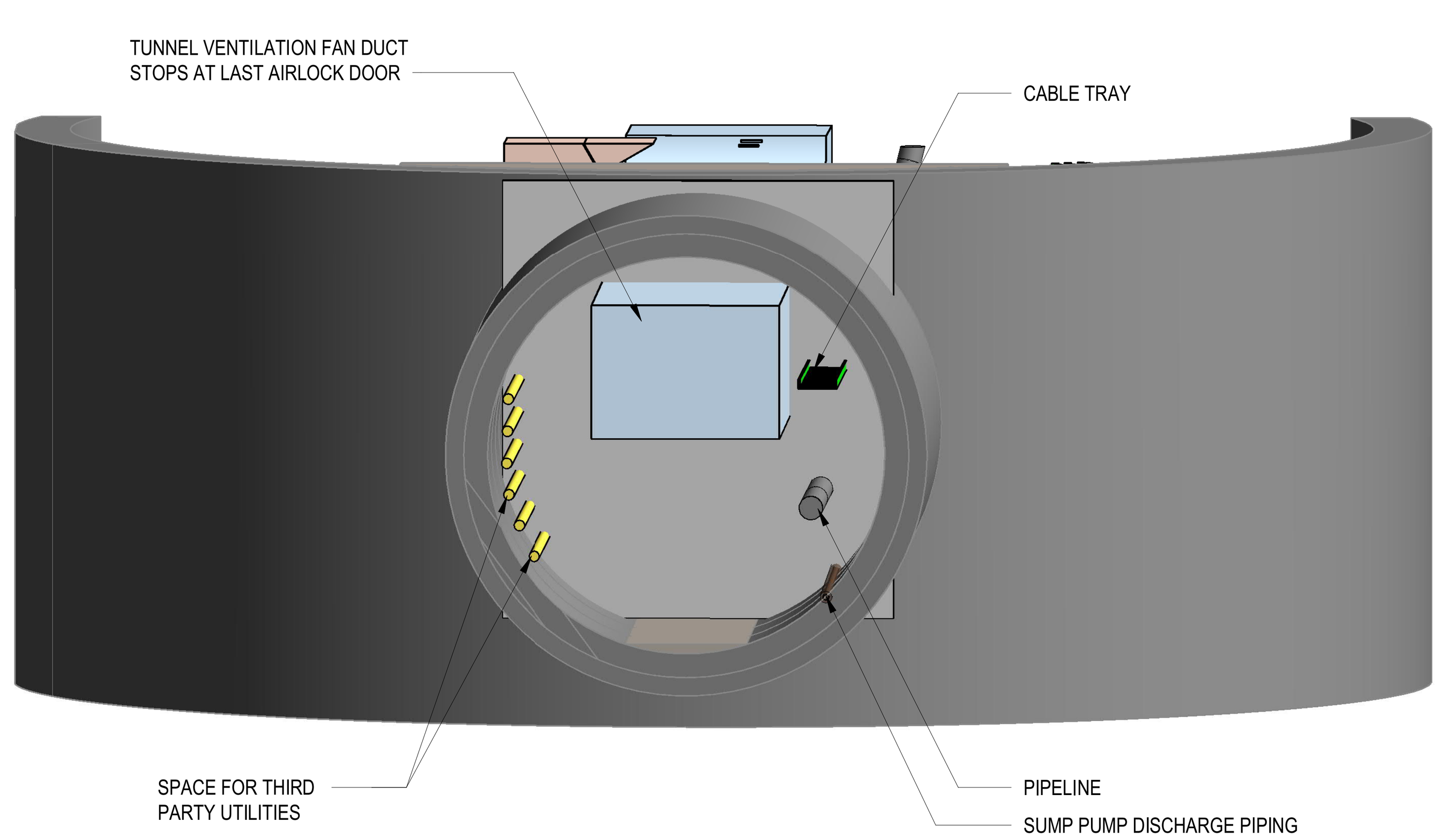
GREAT LAKES TUNNEL PROJECT
TYPICAL SECTION
LAYOUT SHEET
1 OF 3

BY: Author	CHK: Checker	ENG: Designer	ENB APPR: Approver
DATE:		SCALE: 1/4" = 1'-0"	STATUS: DESIGN
DWG. NO.:			REV. NO.:

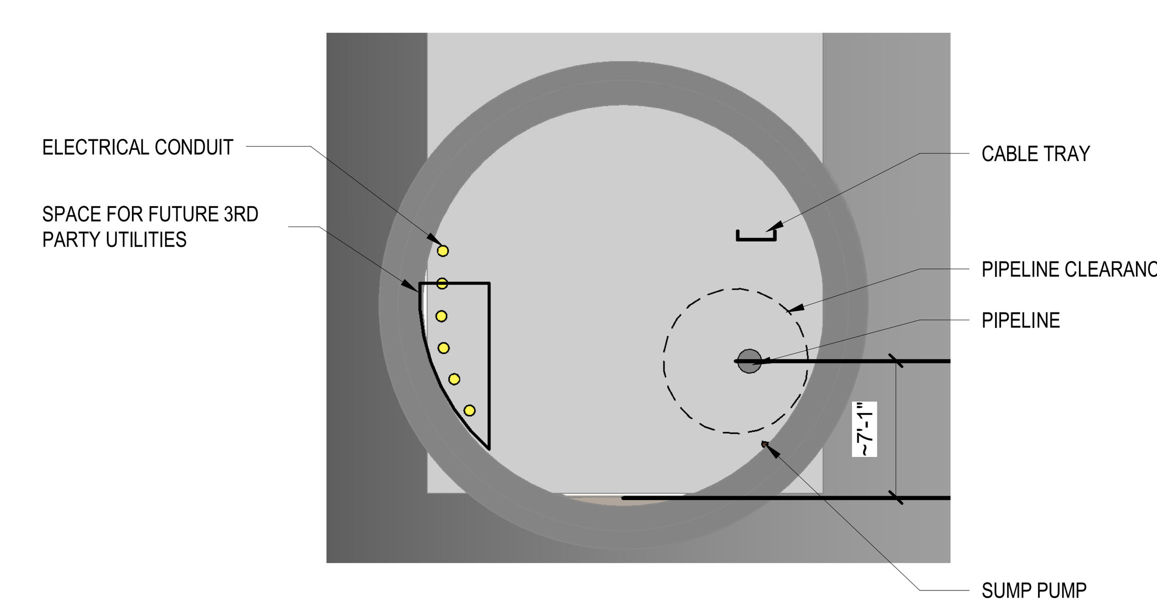
FIGURE 1



1 North Straits Tunnel Entrance
NTS



2 North Straits Tunnel Exit
NTS



3 North Straits Tunnel Entrance
1/8" = 1'-0"

STAMP

ORIGINATING COMPANY

ARUP

ARUP TEXAS INC
10370 RICHMOND AVENUE, SUITE 475
HOUSTON, TX 77042

REF	DRAWING NUMBER	DRAWING TITLE

REFERENCE DRAWINGS

REV NO	REVISION DESCRIPTION	DATE BY	CHK	APPR

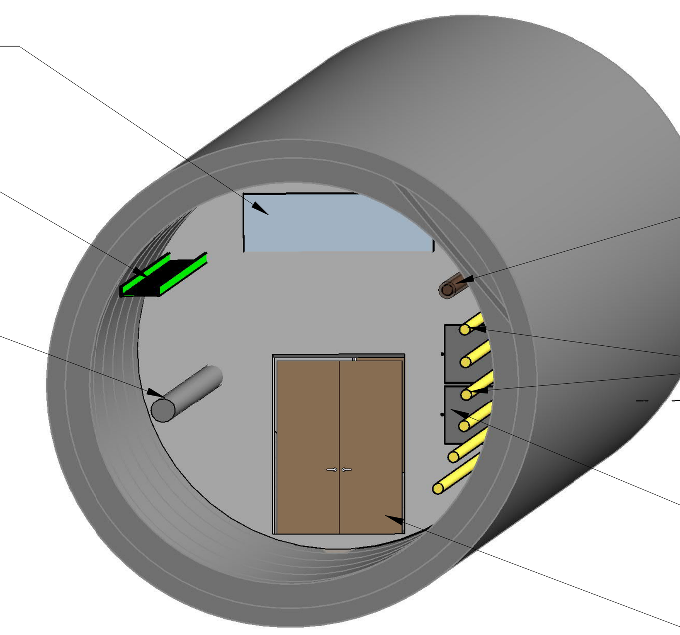
ENBRIDGE ARUP

GREAT LAKES TUNNEL PROJECT
TYPICAL SECTION
LAYOUT SHEET
2 OF 3

BY: Author	CHK: Checker	ENG: Designer	ENB APPR: Approver
DATE:		SCALE: 1/8" = 1'-0"	STATUS: DESIGN

DWG. NO.: REV. NO.:

FIGURE 2



1 Mackinaw Station Portal Tunnel Exit

STAMP

ORIGINATING COMPANY

ARUP

ARUP TEXAS INC
10370 RICHMOND AVENUE, SUITE 475
HOUSTON, TX 77042

REF	DRAWING NUMBER	DRAWING TITLE

REFERENCE DRAWINGS

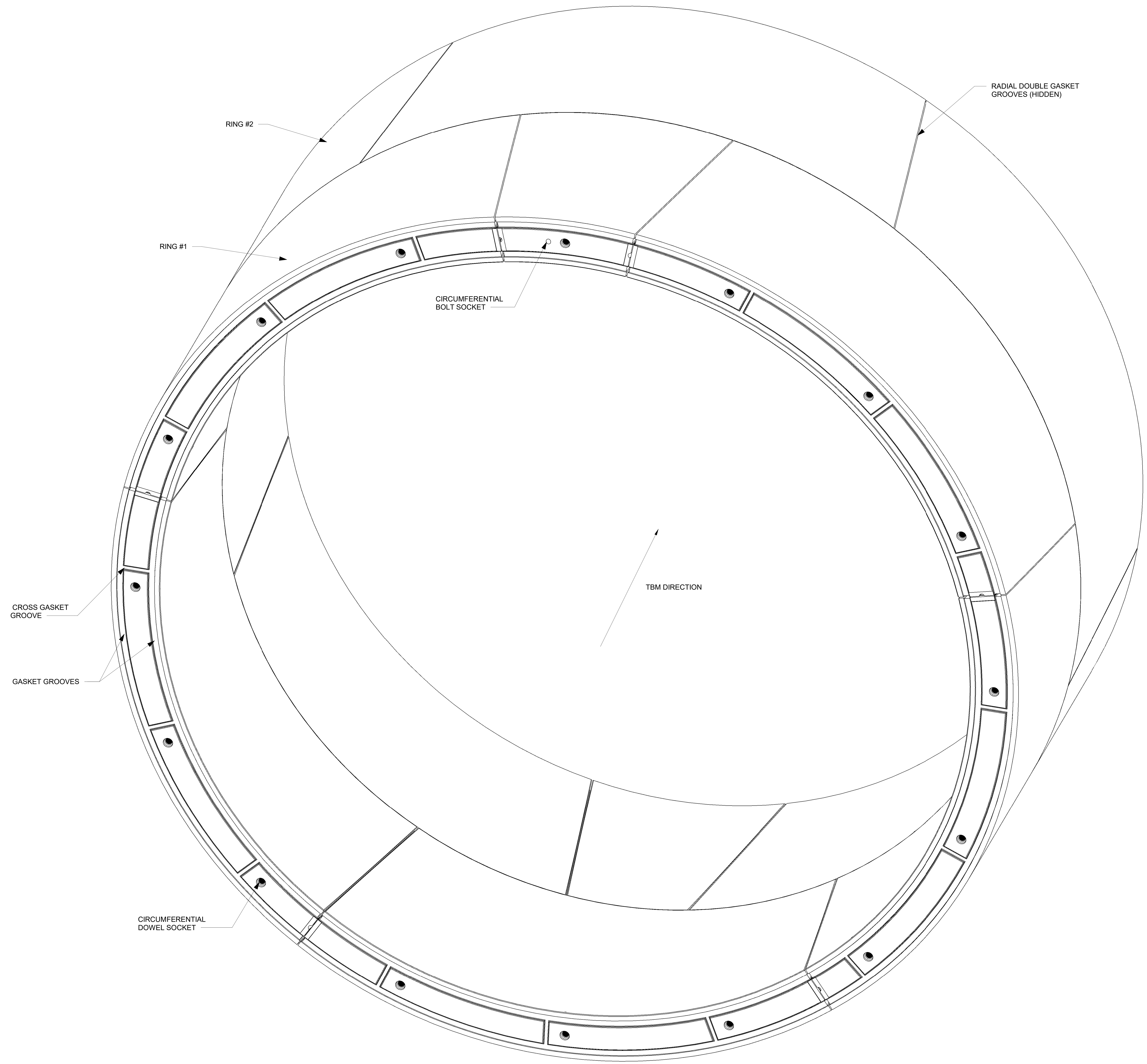
REV NO	REVISION DESCRIPTION	DATE BY	CHK	APPR

ENBRIDGE ARUP

GREAT LAKES TUNNEL PROJECT
TYPICAL SECTION
LAYOUT SHEET
3 OF 3

BY: Author	CHK: Checker	ENG: Designer	ENB APPR: Approver
DATE:		SCALE:	STATUS: DESIGN
DWG. NO.:			REV. NO.:

FIGURE 3



1 ISOMETRIC VIEW

90% REVIEW ISSUE

STAMP

ORIGINATING COMPANY

ARUP

ARUP TEXAS INC
10370 RICHMOND AVENUE, SUITE 475
HOUSTON, TX 77042

REF	DRAWING NUMBER	DRAWING TITLE

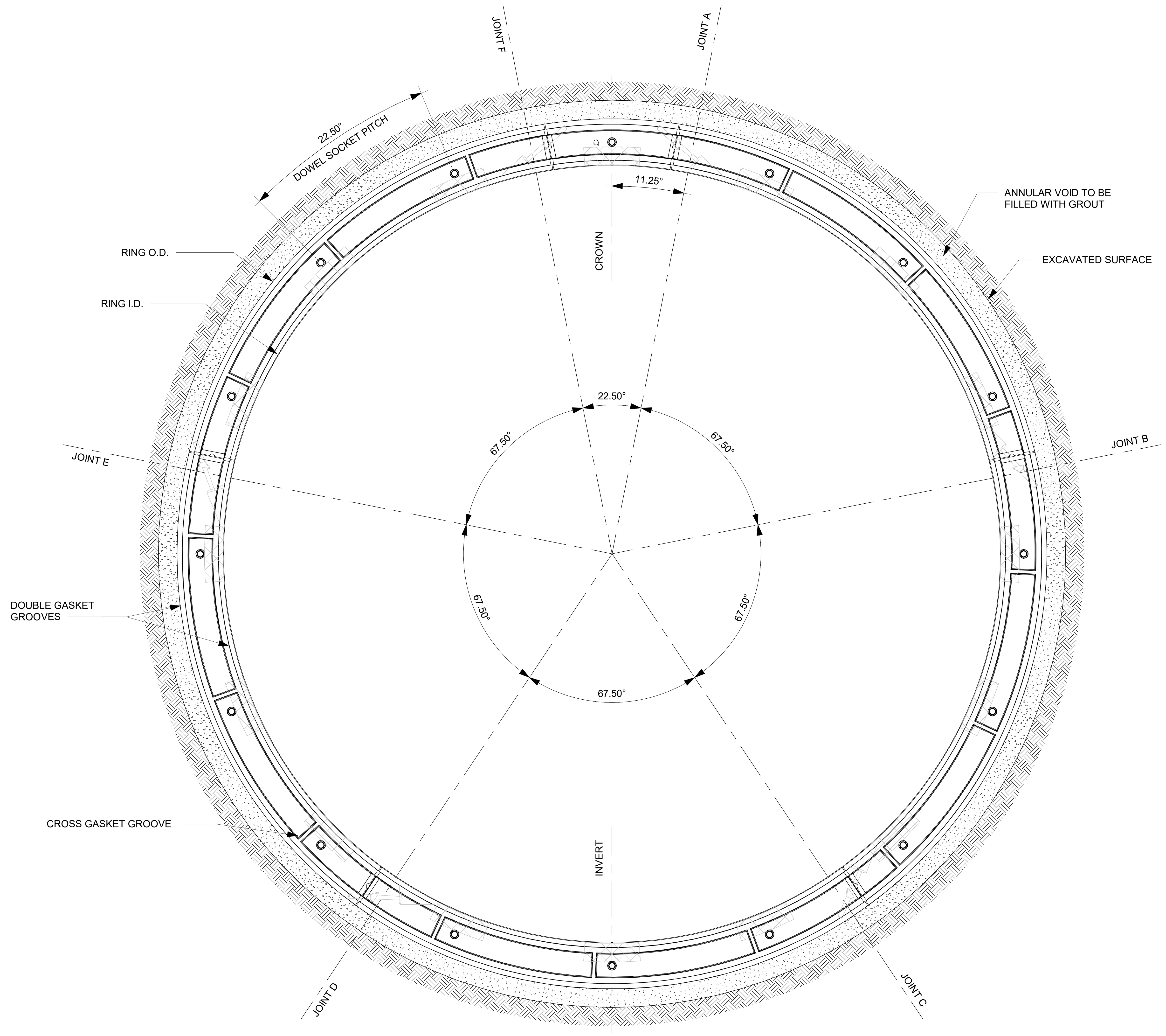
REFERENCE DRAWINGS

REV NO	REVISION DESCRIPTION	DATE BY	CHK	APPR

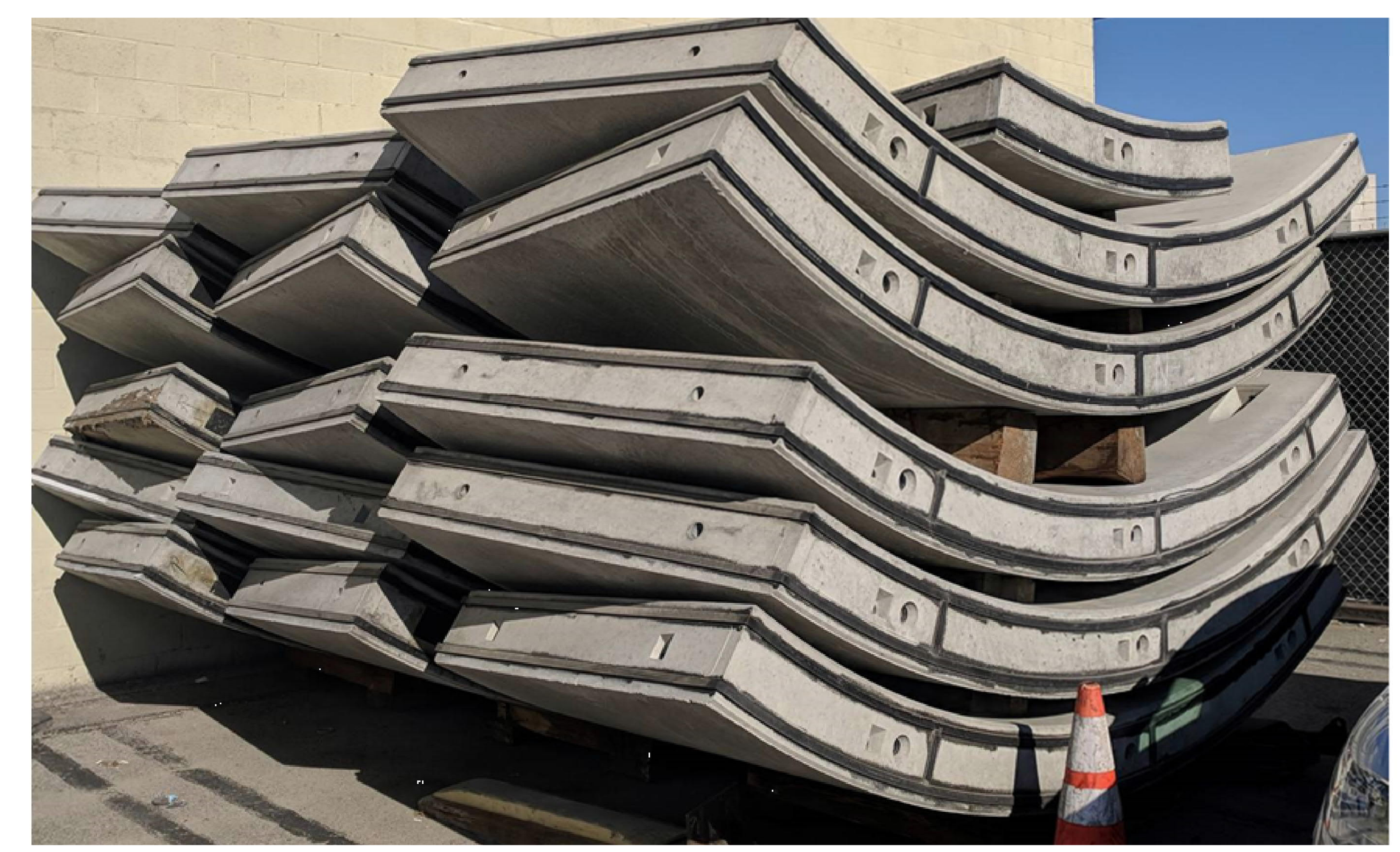
ENBRIDGE ARUP

GREAT LAKES TUNNEL PROJECT
STRAITS TUNNEL
SEGMENTAL TUNNEL LINER
ISOMETRIC VIEW

BY: Author	CHK: Checker	ENG: Designer	ENB APPR: Approver
DATE:		SCALE: 6" = 1'-0"	STATUS: Project Status
DWG. NO.:		FIGURE 4	REV. NO.:



1 ELEVATION
1/2" = 1'-0"



2 SIMILAR PCTL SEGMENTS WITH DOUBLE GASKETS
NTS

90% REVIEW ISSUE

STAMP

ORIGINATING COMPANY

ARUP

ARUP TEXAS INC
10370 RICHMOND AVENUE, SUITE 475
HOUSTON, TX 77042

REF	DRAWING NUMBER	DRAWING TITLE

REFERENCE DRAWINGS

REV NO	REVISION DESCRIPTION	DATE BY	CHK	APPR

ENBRIDGE ARUP

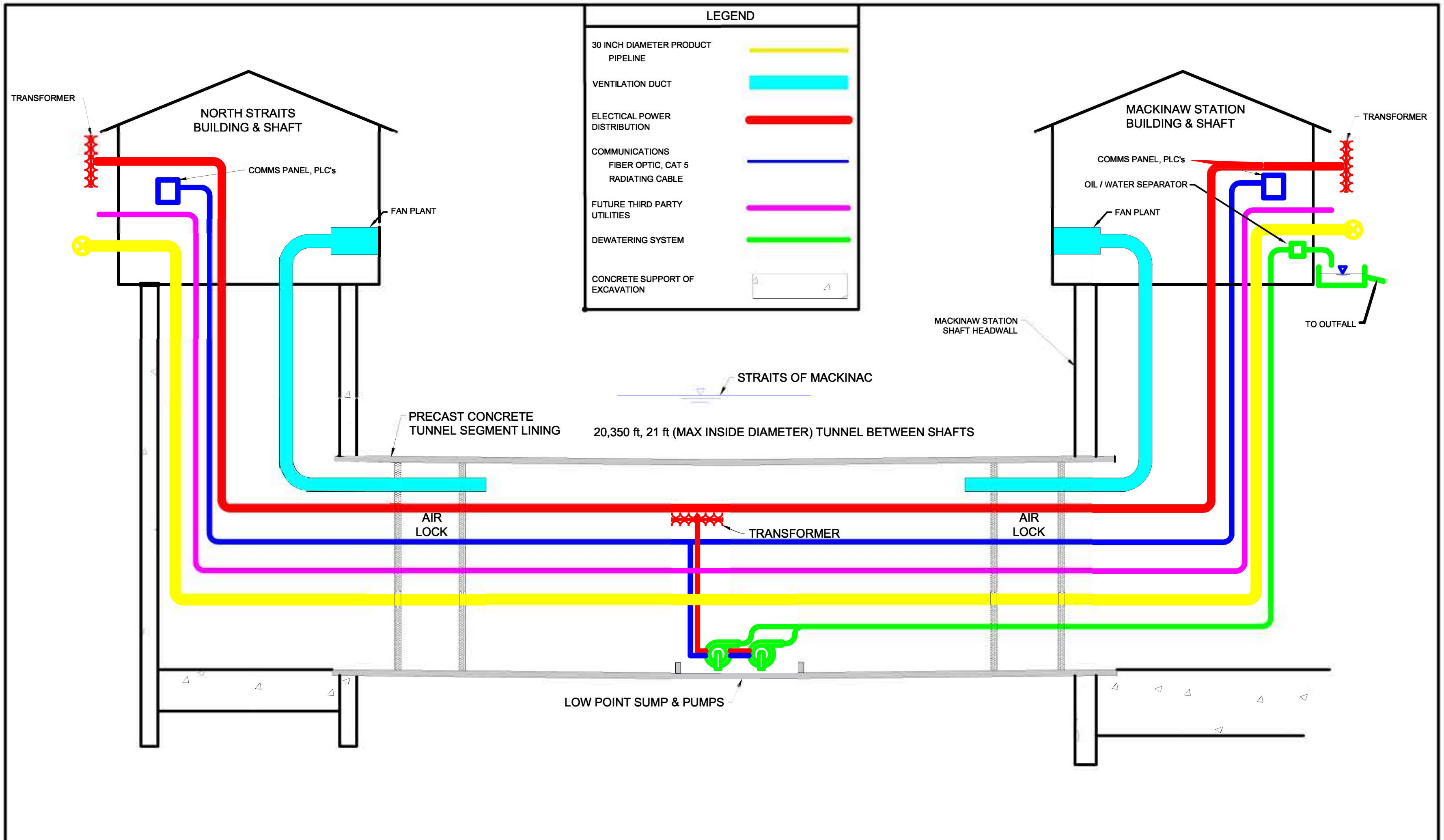
GREAT LAKES TUNNEL PROJECT
STRAITS TUNNEL
SEGMENTAL TUNNEL LINER
LAYOUT GEOMETRY

BY: Author	CHK: Checker	ENG: Designer	ENB APPR: Approver
DATE:		SCALE: 1/2" = 1'-0"	STATUS: Project Status
DWG. NO.:			REV. NO.:

FIGURE 5

ATTACHMENT

2



ATTACHMENT 2

GLTP TUNNEL SYSTEMS DIAGRAM

FIRST DISCOVERY REQUESTS TO ENBRIDGE ENERGY, LIMITED PARTNERSHIP BY THE MICHIGAN PUBLIC SERVICE COMMISSION STAFF

Utility Information Request

☑ Public Document

Docket Numbers: Case No. U-20763 Date of Request: September 10, 2020

Requested From: Enbridge Energy, Limited Partnership Response Due: September 24, 2020

Objected By: Michael Ashton, Counsel

Response By: Aaron Dennis, Engineer Specialist

If you feel your responses are trade secret or privileged, please indicate this on your response.

Request No.	
2	Subject: Drawing Package
Request:	Regarding Page 1 of Exhibit A-7 and the anticipated 0.4 to 0.8 mile of pipe used to tie-in the replacement pipe segment into the existing Line 5 pipeline, please provide detailed maps and schematics showing the locations of: a. Pipe installation and tie-ins on the north and south shores between the existing and replacement pipe segments; b. Any associated fixtures, structures, systems, coating, cathodic protection and other protective measures, or other equipment or appurtenances relating to the tie-ins; and c. Any modifications to existing facilities on the north or south shores including valves, pigging facilities, cathodic protection, control systems, or associated communications equipment.
Objection:	To the extent that this request seeks information concerning the safety and integrity of the replacement pipeline, such as coating, cathodic protection, protective measures, valves, pigging facilities, control systems or associated communications equipment, these items are ultimately subject to the exclusive regulatory authority of the Pipeline and Hazardous Materials Safety Administration, and Enbridge therefore objects as the information sought is irrelevant.
Response:	See attached MPSC Figures.

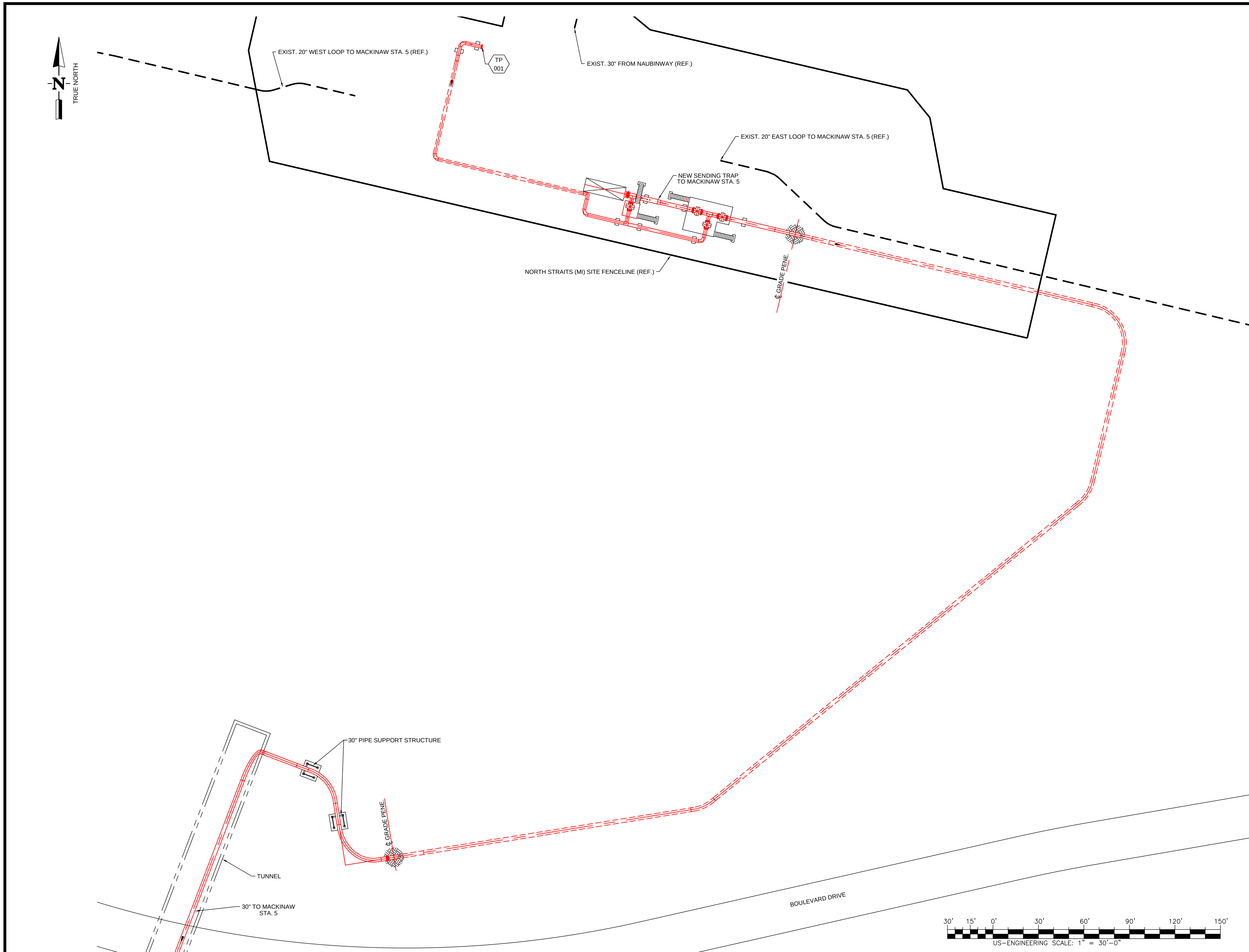


FIGURE 1
STRAITS LINE 5
PROPOSED ROUTE - NORTH STRAITS
STRAITS OF MACKINAC MICHIGAN

Attachment to MPSC IR No. 2

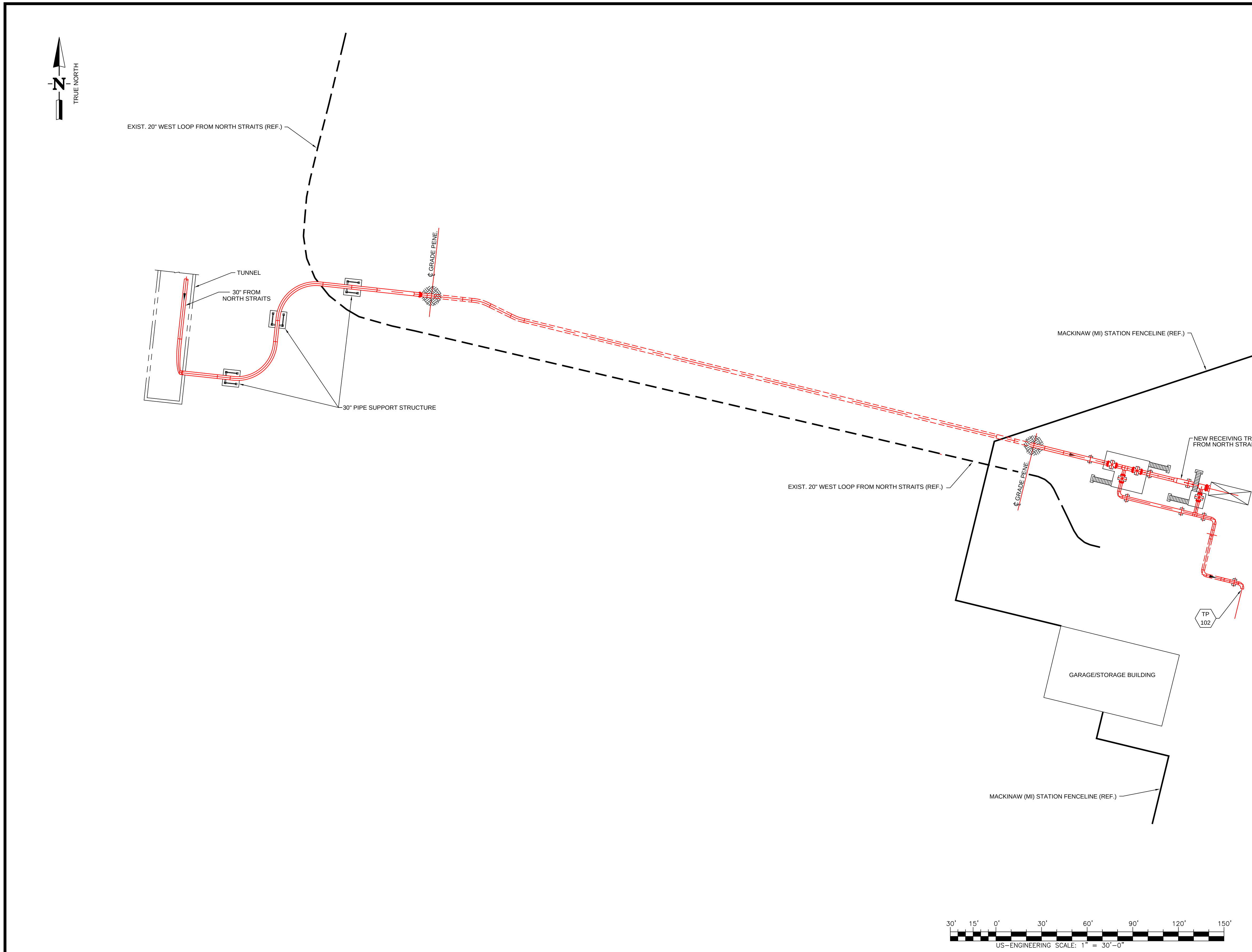


FIGURE 2
STRAITS LINE 5
PROPOSED ROUTE - MACKINAW STATION
STRAITS OF MACKINAC MICHIGAN

EXHIBIT A-14

FIRST DISCOVERY REQUESTS TO ENBRIDGE ENERGY, LIMITED PARTNERSHIP BY THE MICHIGAN PUBLIC SERVICE COMMISSION STAFF

Utility Information Request

☑ Public Document

Docket Numbers: Case No. U-20763 Date of Request: September 10, 2020

Requested From: Enbridge Energy, Limited Partnership Response Due: September 24, 2020

Objection By: Michael Ashton, Counsel

Response By: Aaron Dennis, Engineer Specialist

If you feel your responses are trade secret or privileged, please indicate this on your response.

Request No.	
3	Subject: Pipe Specifications

Request: Regarding Page 3 of Exhibit A-7 that provides partial pipeline specifications, please update Table No. 1 with the following:

a. All pipe, fittings, and appurtenances that will be included in this project, including carrier pipe, launchers/receivers, valves, and associated equipment; and

b. Full specifications of all items listed in (a) above, including the following where applicable:

i. Grade/Yield Strength
ii. Wall Thickness
iii. Diameter
iv. Seam Factor
v. Design Factor
vi. Coating
vii. Manufacturing Standard
viii. Pressure Testing Requirements
ix. Maximum Operating Pressure

Objection: To the extent that this request seeks information concerning the safety and integrity of the replacement pipeline, these issues are ultimately subject to the exclusive regulatory authority of the Pipeline and Hazardous Materials Safety Administration, and Enbridge therefore objects as the information sought is irrelevant.

Response: Without waiving the above objection, additional information concerning the specifications for the pipeline and associated facilities includes the following:

Launcher/Receiver

i. Closure Door T.D. Williamson D2000, Part number 19-6736-0600-54 or equivalent.

ii. Materials Enbridge H1DCA piping specification (See H1DCA Piping Specification).
iii. Valves Enbridge H1DCA piping specification (See H1DCA Piping Specification)

Main 30" pipeline:

i.	Grade/Yield Strength	API 5L X70 PSL2
ii.	Wall Thickness	0.625"
iii.	Diameter	30" OD
iv.	Seam Factor	1.0
v.	Design Factor	0.6
vi.	Coating	
a.	Above Ground	Enbridge System P-210 (Shop and Field Painting)
b.	Below Ground	Enbridge System C-010 (Fusion Bond Epoxy (FBE))
c.	In the Tunnel	Enbridge System C-020 (FBE with Abrasive Coating)
vii.	Manufacturing Standard:	Seamless or SAW
viii.	Pressure Testing Requirements:	1800 PSIG held continuous for 4 hours.
ix.	Maximum Operating Pressure:	1440 PSIG

Other Pipe:

i.	Grade/Yield Strength	Enbridge H1DCA piping specification (See H1DCA Piping Specification).
ii.	Wall Thickness	Enbridge H1DCA piping specification (See H1DCA Piping Specification).
iii.	Diameter	Various
iv.	Seam Factor	1.0
v.	Design Factor	0.6
vi.	Coating	Enbridge System P-210 (Shop and Field Painting)
vii.	Manufacturing Standard:	See attached H1DCA piping specification (See H1DCA Piping Specification).
viii.	Pressure Testing Requirements:	1800 PSIG (1.25 x MAOP) held continuous for 4 hours.
ix.	Maximum Operating Pressure:	1440 PSIG

Attachment to Enbridge Response to MPSC IR No 3

ENBRIDGE

Table E.11 – HVP Above-Grade Class 600, US (H1DCA)

PIPE CLASS:	H1DCA	Revision 0
COMMODITY:	HVP LIQUIDS (NON-SOUR SERVICE)	
SERVICE LOCATION:	ABOVE-GRADE IN STATIONS AND TERMINALS, US	
PRESSURE RATING:	CLASS 600	
BASIC MATERIAL:	CARBON STEEL	
MINIMUM DESIGN TEMPERATURE:	PER ENBRIDGE STANDARD D06-102, TABLE 4.2	
DESIGN CODE:	ASME B31.4	
CORROSION ALLOWANCE:	0	
HYDROTEST PRESSURE:	PER ENBRIDGE SPECIFICATION FCS-014: MINIMUM 2160 psi(g), MAXIMUM 2250 psi(g)	
NON-DESTRUCTIVE EXAM.:	PER ENBRIDGE STANDARD UFC-021	
PWHT:	PER CODE AND ENBRIDGE SPECIFICATION FCS-023	
GENERAL NOTES:	2, 5, 6	
	* in the "SUB" column denotes approved material substitution	

PRESSURE & TEMPERATURE RATINGS (Note 1):

TEMPERATURE, °F	100	133	200	248
PRESSURE, psi(g)	1440	1440	1360	1336

DP / DT LIMITED BY: FLANGE

NOTE	SIZE RANGE (NPS)	COMMODITY CODE	SUB	DESCRIPTION	EQUIPMENT SPEC	REV
				PIPE		
18	1/2 - 1 1/2			PIPE, SMLS, API 5L, PSL2 Gr. B, PE, SCH 80	EES101	
4	1/2 - 1 1/2		*	PIPE, SMLS, ASTM A333 Gr. 6, PE, SCH 80	EES101	
18	1/2 - 1 1/2		*	PIPE, HF ERW, API 5L, PSL2 Gr. B, PE, SCH 80	EES101	
18	2 - 6			PIPE, SMLS, API 5L, PSL2 Gr. B, BE, SCH 80	EES101	
4	2 - 6		*	PIPE, SMLS, ASTM A333 Gr. 6, BE, SCH 80	EES101	
18	2 - 6		*	PIPE, HF ERW, API 5L, PSL2 Gr. B, BE, SCH 80	EES101	
18	8			PIPE, HF ERW, API 5L, PSL2 Gr. B, BE, 0.322" WT	EES101	
18	8		*	PIPE, SMLS, API 5L, PSL2 Gr. B, BE, 0.322" WT	EES101	
4	8		*	PIPE, SMLS, ASTM A333 Gr. 6, BE, 0.322" WT	EES101	
18	10 - 12			PIPE, HF ERW, API 5L, PSL2 Gr. B, BE, 0.5" WT	EES101	
18	10 - 12		*	PIPE, SMLS, API 5L, PSL2 Gr. B, BE, 0.5" WT	EES101	
4	10 - 12		*	PIPE, SMLS, ASTM A333 Gr. 6, BE, 0.5" WT	EES101	
18	16			PIPE, HF ERW, API 5L, PSL2 Gr. X42, BE, 0.5" WT	EES101	
18	16		*	PIPE, SMLS, API 5L, PSL2 Gr. X42, BE, 0.5" WT	EES101	
18	18 - 20			PIPE, HF ERW, API 5L, PSL2 Gr. X52, BE, 0.5" WT	EES101	
18	18 - 20		*	PIPE, SMLS, API 5L, PSL2 Gr. X52, BE, 0.5" WT	EES101	
18	22 - 24			PIPE, HF ERW, API 5L, PSL2 Gr. X60, BE, 0.5" WT	EES101	
18	22 - 24		*	PIPE, SMLS, API 5L, PSL2 Gr. X60, BE, 0.5" WT	EES101	
3, 18	26			PIPE, SAW, API 5L, PSL2 Gr. X70, BE, 0.5" WT	EES103	
3, 18	30 - 36			PIPE, SAW, API 5L, PSL2 Gr. X70, BE, 0.625" WT	EES103	
3, 18	42			PIPE, SAW, API 5L, PSL2 Gr. X70, BE, 0.75" WT	EES103	
3, 18	48			PIPE, SAW, API 5L, PSL2 Gr. X70, BE, 0.875" WT	EES103	
				FLANGES		
	1/2 - 1 1/2			FLANGE, RFSW, ASME B16.5, ASTM A350 LF2 CL 1, CL 600, SCH 80		
	2 - 6			FLANGE, RFWN, ASME B16.5, ASTM A350 LF2 CL 1, CL 600, SCH 80	EES023	
	8			FLANGE, RFWN, ASME B16.5, ASTM A350 LF2 CL 1, CL 600, SCH STD	EES023	
	10 - 12			FLANGE, RFWN, ASME B16.5, ASTM A350 LF2 CL 1, CL 600, SCH XS	EES023	
	12		*	FLANGE, RFWN, MSS SP-44, ASTM A350 LF2 CL 1, CL 600, SCH XS	EES023	
	16			FLANGE, RFWN, MSS SP-44, ASTM A707 L2 CL 1, CL 600, SCH XS	EES023	
	18 - 20			FLANGE, RFWN, MSS SP-44, ASTM A707 L2 CL 2, CL 600, SCH XS	EES023	
	22 - 24			FLANGE, RFWN, MSS SP-44, ASTM A707 L2 CL 3, CL 600, SCH XS	EES023	
	26			FLANGE, RFWN, MSS SP-44, ASTM A707 L2 CL 3, CL 600, BORE TAPERED TO MATCH PIPE w/ SCH XS WT, 0.625" HUB THICKNESS	EES023	

Attachment to Enbridge Response to MPSC IR No 3

ENBRIDGE

Table E.11 – HVP Above-Grade Class 600, US (H1DCA)

NOTE	SIZE RANGE (NPS)	COMMODITY CODE	SUB	DESCRIPTION	EQUIPMENT SPEC	REV
	30 - 36			FLANGE, RFWN, MSS SP-44, ASTM A707 L2 CL 3, CL 600, BORE TAPERED TO MATCH PIPE w/ SCH 30 WT, 0.75" HUB THICKNESS	EES023	
	42			FLANGE, RFWN, MSS SP-44, ASTM A707 L2 CL 3, CL 600, BORE TO MATCH PIPE w/ 0.75" WT	EES023	
	48			FLANGE, RFWN, MSS SP-44, ASTM A707 L2 CL 3, CL 600, BORE TAPERED TO MATCH PIPE w/ 0.875" WT, 1.062" HUB THICKNESS	EES023	
	6 - 24			FLANGE, LAP JOINT, ASME B16.5, ASTM A350 LF2 CL 1, CL 600	EES023	
	1/2 - 12			FLANGE, RF BLIND, ASME B16.5, ASTM A350 LF2 CL 1, CL 600	EES023	
	12		*	FLANGE, RF BLIND, MSS SP-44, ASTM A350 LF2 CL 1, CL 600	EES023	
	16			FLANGE, RF BLIND, MSS SP-44, ASTM A707 L2 CL 1, CL 600	EES023	
	18 - 20			FLANGE, RF BLIND, MSS SP-44, ASTM A707 L2 CL 2, CL 600	EES023	
	22 - 48			FLANGE, RF BLIND, MSS SP-44, ASTM A707 L2 CL 3, CL 600	EES023	
				SPECIALTY FLANGES		
14	6 - 12			FLANGE, DOUBLE FACED RF BLIND, ASTM A350 LF2 CL 1, CL 600, PER D06-104 FIG. A.1	EES023	
14	16 - 36			FLANGE, DOUBLE FACED RF BLIND, ASTM A516 Gr. 70 N, CL 600, PER D06-104 FIG. A.1, IMPACT TESTED	EES023	
	1/2 - 24			BLANK, RF PADDLE, ASME B16.48, ASTM A516 Gr. 70 N, CL 600, IMPACT TESTED	EES023	
14	6 - 36			SPACER RING, RF WIDE, ASTM A516 Gr. 70 N, CL 600, PER D06-104 FIG. A.1, IMPACT TESTED	EES023	
14	6 - 36			SPACER RING, RF THIN, ASTM A516 Gr. 70 N, CL 600, PER D06-104 FIG. A.2, IMPACT TESTED	EES023	
	1/2 - 6			FLANGE, RFWN ORIFICE, ASME B16.36, ASTM A350 LF2 CL 1, CL 600, SCH 80, 2 TAPS, NPS 1/2 SW	EES023	
	8			FLANGE, RFWN ORIFICE, ASME B16.36, ASTM A350 LF2 CL 1, CL 600, SCH STD, 2 TAPS, NPS 1/2 SW	EES023	
	10 - 12			FLANGE, RFWN ORIFICE, ASME B16.36, ASTM A350 LF2 CL 1, CL 600, SCH XS, 2 TAPS, NPS 1/2 SW	EES023	
				WELD FITTINGS		
	1/2 - 1 1/2			ELBOW, 45, ASME B16.11, ASTM A350 LF2 CL 1, CL 3000, SW		
	2 - 6			ELBOW, 45 LR, ASME B16.9, ASTM A420 WPL6, BW, SCH 80	EES023	
	8			ELBOW, 45 LR, ASME B16.9, ASTM A420 WPL6, BW, SCH STD	EES023	
	10 - 12			ELBOW, 45 LR, ASME B16.9, ASTM A420 WPL6, BW, SCH XS	EES023	
	16			ELBOW, 45 LR, ASME B16.9, ASTM A420 WPL9, BW, SCH XS	EES023	
	16		*	ELBOW, 45 LR, MSS SP-75, Gr. WPHY 42, BW, SCH XS	EES023	
	16		*	ELBOW, 45 LR, MSS SP-75, Gr. WPHY 46, BW, SCH XS	EES023	
	18 - 20			ELBOW, 45 LR, MSS SP-75, Gr. WPHY 52, BW, SCH XS	EES023	
	22 - 24			ELBOW, 45 LR, MSS SP-75, Gr. WPHY 60, BW, SCH XS	EES023	
	26			ELBOW, 45 LR, MSS SP-75, Gr. WPHY 70, BW, SCH XS	EES023	
	30 - 36			ELBOW, 45 LR, MSS SP-75, Gr. WPHY 70, BW, SCH 30	EES023	
	42			ELBOW, 45 LR, MSS SP-75, Gr. WPHY 70, BW, SCH TO MATCH PIPE w/ 0.75" WT	EES023	
	48			ELBOW, 45 LR, MSS SP-75, Gr. WPHY 70, BW, SCH TO MATCH PIPE w/ 0.875" WT	EES023	
	1/2 - 1 1/2			ELBOW, 90, ASME B16.11, ASTM A350 LF2 CL 1, CL 3000, SW		
	2 - 6			ELBOW, 90 LR, ASME B16.9, ASTM A420 WPL6, BW, SCH 80	EES023	
	8			ELBOW, 90 LR, ASME B16.9, ASTM A420 WPL6, BW, SCH STD	EES023	
	10 - 12			ELBOW, 90 LR, ASME B16.9, ASTM A420 WPL6, BW, SCH XS	EES023	
	16			ELBOW, 90 LR, ASME B16.9, ASTM A420 WPL9, BW, SCH XS	EES023	
	16		*	ELBOW, 90 LR, MSS SP-75, Gr. WPHY 42, BW, SCH XS	EES023	
	16		*	ELBOW, 90 LR, MSS SP-75, Gr. WPHY 46, BW, SCH XS	EES023	
	18 - 20			ELBOW, 90 LR, MSS SP-75, Gr. WPHY 52, BW, SCH XS	EES023	
	22 - 24			ELBOW, 90 LR, MSS SP-75, Gr. WPHY 60, BW, SCH XS	EES023	
	26			ELBOW, 90 LR, MSS SP-75, Gr. WPHY 70, BW, SCH XS	EES023	
	30 - 36			ELBOW, 90 LR, MSS SP-75, Gr. WPHY 70, BW, SCH 30	EES023	
	42			ELBOW, 90 LR, MSS SP-75, Gr. WPHY 70, BW, SCH TO MATCH PIPE w/ 0.75" WT	EES023	
	48			ELBOW, 90 LR, MSS SP-75, Gr. WPHY 70, BW, SCH TO MATCH PIPE w/ 0.875" WT	EES023	

Attachment to Enbridge Response to MPSC IR No 3

Table E.11 – HVP Above-Grade Class 600, US (H1DCA)

NOTE	SIZE RANGE (NPS)		COMMODITY CODE	SUB	DESCRIPTION	EQUIPMENT SPEC	REV
	1/2 - 1 1/2				TEE, STR, ASME B16.11, ASTM A350 LF2 CL 1, CL 3000, SW		
	2 - 6				TEE, STR, ASME B16.9, ASTM A420 WPL6, BW, SCH 80	EES023	
	8				TEE, STR, ASME B16.9, ASTM A420 WPL6, BW, SCH STD	EES023	
	10 - 12				TEE, STR, ASME B16.9, ASTM A420 WPL6, BW, SCH XS	EES023	
	16				TEE, STR, ASME B16.9, ASTM A420 WPL9, BW, SCH XS	EES023	
	16			*	TEE, STR, MSS SP-75, Gr. WPHY 42, BW, SCH XS	EES023	
	16			*	TEE, STR, MSS SP-75, Gr. WPHY 46, BW, SCH XS	EES023	
	18 - 20				TEE, STR, MSS SP-75, Gr. WPHY 52, BW, SCH XS	EES023	
	22 - 24				TEE, STR, MSS SP-75, Gr. WPHY 60, BW, SCH XS	EES023	
	26				TEE, STR, MSS SP-75, Gr. WPHY 70, BW, SCH XS	EES023	
	30 - 36				TEE, STR, MSS SP-75, Gr. WPHY 70, BW, SCH 30	EES023	
	42				TEE, STR, MSS SP-75, Gr. WPHY 70, BW, SCH TO MATCH PIPE w/ 0.75" WT	EES023	
	48				TEE, STR, MSS SP-75, Gr. WPHY 70, BW, SCH TO MATCH PIPE w/ 0.875" WT	EES023	
	1/2 - 1 1/2				CAP, ASME B16.11, ASTM A350 LF2 CL 1, CL 3000, SW		
	2 - 6				CAP, ASME B16.9, ASTM A420 WPL6, BW, SCH 80	EES023	
	8				CAP, ASME B16.9, ASTM A420 WPL6, BW, SCH STD	EES023	
	10				CAP, ASME B16.9, ASTM A420 WPL6, BW, SCH XS	EES023	
	1/2 - 1 1/2				COUPLING, FULL, ASME B16.11, ASTM A350 LF2 CL 1, CL 3000, SW		
	6				STUB END, LONG PATTERN, ASME B16.5, ASTM A420 WPL6, BW, SCH 80	EES023	
	8				STUB END, LONG PATTERN, ASME B16.5, ASTM A420 WPL6, BW, SCH STD	EES023	
	10 - 12				STUB END, LONG PATTERN, ASME B16.5, ASTM A420 WPL6, BW, SCH XS	EES023	
20	16				STUB END, LONG PATTERN, ASME B16.9, ASTM A420 WPL9, BW, SCH XS	EES023	
					NIPPLES		
4	1/2 - 1 1/2				NIPPLE, 4" LONG, ASTM A333 Gr. 6, SMLS, PBE, SCH 160		
4	1/2 - 1 1/2				NIPPLE, 6" LONG, ASTM A333 Gr. 6, SMLS, PBE, SCH 160		
	LARGE END	**SMALL END**			**SWAGES**		
	3/4 - 1 1/2	1/2 - 1 1/4			SWAGE, CONC, MSS SP-95, ASTM A420 WPL6, PBE, SCH 80		
	2 - 4	1/2 - 1 1/2			SWAGE, CONC, MSS SP-95, ASTM A420 WPL6, BLE/PSE, SCH 80		
	3/4 - 1 1/2	1/2 - 1 1/4			SWAGE, ECC, MSS SP-95, ASTM A420 WPL6, PBE, SCH 80		
	2 - 4	1/2 - 1 1/2			SWAGE, ECC, MSS SP-95, ASTM A420 WPL6, BLE/PSE, SCH 80		
	LARGE END	**SMALL END**			**REDUCING WELD FITTINGS**		
	3 - 6	2 - 4			REDUCER, CONC, ASME B16.9, ASTM A420 WPL6, BW, SCH 80	EES023	
	8	4 - 6			REDUCER, CONC, ASME B16.9, ASTM A420 WPL6, BW, LRG END SCH STD x SML END SCH 80	EES023	
	10 - 12	4 - 6			REDUCER, CONC, ASME B16.9, ASTM A420 WPL6, BW, LRG END SCH XS x SML END SCH 80	EES023	
	10 - 12	8			REDUCER, CONC, ASME B16.9, ASTM A420 WPL6, BW, LRG END SCH XS x SML END SCH STD	EES023	
	12	10			REDUCER, CONC, ASME B16.9, ASTM A420 WPL6, BW, SCH XS	EES023	
	16	8			REDUCER, CONC, ASME B16.9, ASTM A420 WPL9, BW, LRG END SCH XS x SML END SCH STD	EES023	
	16	8		*	REDUCER, CONC, MSS SP-75, Gr. WPHY 42, BW, LRG END SCH XS x SML END SCH STD	EES023	
	16	8		*	REDUCER, CONC, MSS SP-75, Gr. WPHY 46, BW, LRG END SCH XS x SML END SCH STD	EES023	
	16	10 - 12			REDUCER, CONC, ASME B16.9, ASTM A420 WPL9, BW, SCH XS	EES023	
	16	10 - 12		*	REDUCER, CONC, MSS SP-75, Gr. WPHY 42, BW, SCH XS	EES023	
	16	10 - 12		*	REDUCER, CONC, MSS SP-75, Gr. WPHY 46, BW, SCH XS	EES023	
	18 - 20	10 - 18			REDUCER, CONC, MSS SP-75, Gr. WPHY 52, BW, SCH XS	EES023	
	22 - 24	16 - 22			REDUCER, CONC, MSS SP-75, Gr. WPHY 60, BW, SCH XS	EES023	
	26	18 - 24			REDUCER, CONC, MSS SP-75, Gr. WPHY 70, BW, SCH XS	EES023	
	30 - 36	20 - 26			REDUCER, CONC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH 30 x SML END SCH XS	EES023	
	34 - 36	30 - 34			REDUCER, CONC, MSS SP-75, Gr. WPHY 70, BW, SCH 30	EES023	

Attachment to Enbridge Response to MPSC IR No 3

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Table E.11 – HVP Above-Grade Class 600, US (H1DCA)

NOTE	SIZE RANGE (NPS)		COMMODITY CODE	SUB	DESCRIPTION	EQUIPMENT SPEC	REV
	42	22 - 26			REDUCER, CONC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH TO MATCH PIPE w/ 0.75" WT x SML END SCH XS	EES023	
	42	30 - 36			REDUCER, CONC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH TO MATCH PIPE w/ 0.75" WT x SML END SCH 30	EES023	
	48	24 - 26			REDUCER, CONC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH TO MATCH PIPE w/ 0.875" WT x SML END SCH XS	EES023	
	48	30 - 36			REDUCER, CONC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH TO MATCH PIPE w/ 0.875" WT x SML END SCH 30	EES023	
	48	42			REDUCER, CONC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH TO MATCH PIPE w/ 0.875" WT x SML END SCH TO MATCH PIPE w/ 0.75" WT	EES023	
	3 - 6	2 - 4			REDUCER, ECC, ASME B16.9, ASTM A420 WPL6, BW, SCH 80	EES023	
	8	4 - 6			REDUCER, ECC, ASME B16.9, ASTM A420 WPL6, BW, LRG END SCH STD x SML END SCH 80	EES023	
	10 - 12	4 - 6			REDUCER, ECC, ASME B16.9, ASTM A420 WPL6, BW, LRG END SCH XS x SML END SCH 80	EES023	
	10 - 12	8			REDUCER, ECC, ASME B16.9, ASTM A420 WPL6, BW, LRG END SCH XS x SML END SCH STD	EES023	
	12	10			REDUCER, ECC, ASME B16.9, ASTM A420 WPL6, BW, SCH XS	EES023	
	16	8			REDUCER, ECC, ASME B16.9, ASTM A420 WPL9, BW, LRG END SCH XS x SML END SCH STD	EES023	
	16	8		*	REDUCER, ECC, MSS SP-75, Gr. WPHY 42, BW, LRG END SCH XS x SML END SCH STD	EES023	
	16	8		*	REDUCER, ECC, MSS SP-75, Gr. WPHY 46, BW, LRG END SCH XS x SML END SCH STD	EES023	
	16	10 - 12			REDUCER, ECC, ASME B16.9, ASTM A420 WPL9, BW, SCH XS	EES023	
	16	10 - 12		*	REDUCER, ECC, MSS SP-75, Gr. WPHY 42, BW, SCH XS	EES023	
	16	10 - 12		*	REDUCER, ECC, MSS SP-75, Gr. WPHY 46, BW, SCH XS	EES023	
	18 - 20	10 - 18			REDUCER, ECC, MSS SP-75, Gr. WPHY 52, BW, SCH XS	EES023	
	22 - 24	16 - 22			REDUCER, ECC, MSS SP-75, Gr. WPHY 60, BW, SCH XS	EES023	
	26	18 - 24			REDUCER, ECC, MSS SP-75, Gr. WPHY 70, BW, SCH XS	EES023	
	30 - 36	20 - 26			REDUCER, ECC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH 30 x SML END SCH XS	EES023	
	34 - 36	30 - 34			REDUCER, ECC, MSS SP-75, Gr. WPHY 70, BW, SCH 30	EES023	
	42	22 - 26			REDUCER, ECC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH TO MATCH PIPE w/ 0.75" WT x SML END SCH XS	EES023	
	42	30 - 36			REDUCER, ECC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH TO MATCH PIPE w/ 0.75" WT x SML END SCH 30	EES023	
	48	24 - 26			REDUCER, ECC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH TO MATCH PIPE w/ 0.875" WT x SML END SCH XS	EES023	
	48	30 - 36			REDUCER, ECC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH TO MATCH PIPE w/ 0.875" WT x SML END SCH 30	EES023	
	48	42			REDUCER, ECC, MSS SP-75, Gr. WPHY 70, BW, LRG END SCH TO MATCH PIPE w/ 0.875" WT x SML END SCH TO MATCH PIPE w/ 0.75" WT	EES023	
	RUN	**BRANCH**					
	3/4 - 1 1/2	1/2 - 1 1/4			TEE, RED, ASME B16.11, ASTM A350 LF2 CL 1, CL 3000, SW	EES023	
21	3 - 6	2 - 4			TEE, RED, ASME B16.9, ASTM A420 WPL6, BW, SCH 80	EES023	
	8	4 - 6			TEE, RED, ASME B16.9, ASTM A420 WPL6, BW, RUN SCH STD x BRANCH SCH 80	EES023	
21	10 - 12	4 - 6			TEE, RED, ASME B16.9, ASTM A420 WPL6, BW, RUN SCH XS x BRANCH SCH 80	EES023	
	10 - 12	8			TEE, RED, ASME B16.9, ASTM A420 WPL6, BW, RUN SCH XS x BRANCH SCH STD	EES023	
	12	10			TEE, RED, ASME B16.9, ASTM A420 WPL6, BW, SCH XS	EES023	
	16	6			TEE, RED, ASME B16.9, ASTM A420 WPL9, BW, RUN SCH XS x BRANCH SCH 80	EES023	
	16	6		*	TEE, RED, MSS SP-75, Gr. WPHY 42, BW, RUN SCH XS x BRANCH SCH 80	EES023	
	16	6		*	TEE, RED, MSS SP-75, Gr. WPHY 46, BW, RUN SCH XS x BRANCH SCH 80	EES023	
	16	8			TEE, RED, ASME B16.9, ASTM A420 WPL9, BW, RUN SCH XS x BRANCH SCH STD	EES023	
	16	8		*	TEE, RED, MSS SP-75, Gr. WPHY 42, BW, RUN SCH XS x BRANCH SCH STD	EES023	
	16	8		*	TEE, RED, MSS SP-75, Gr. WPHY 46, BW, RUN SCH XS x BRANCH SCH STD	EES023	
	16	10 - 12			TEE, RED, ASME B16.9, ASTM A420 WPL9, BW, SCH XS	EES023	
	16	10 - 12		*	TEE, RED, MSS SP-75, Gr. WPHY 42, BW, SCH XS	EES023	
	16	10 - 12		*	TEE, RED, MSS SP-75, Gr. WPHY 46, BW, SCH XS	EES023	
	18 - 20	8			TEE, RED, MSS SP-75, Gr. WPHY 52, BW, RUN SCH XS x BRANCH SCH STD	EES023	
	18 - 20	10 - 18			TEE, RED, MSS SP-75, Gr. WPHY 52, BW, SCH XS	EES023	

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ENBRIDGE

Table E.11 – HVP Above-Grade Class 600, US (H1DCA)

NOTE	SIZE RANGE (NPS)		COMMODITY CODE	SUB	DESCRIPTION	EQUIPMENT SPEC	REV
	22 - 24	10 - 22			TEE, RED, MSS SP-75, Gr. WPHY 60, BW, SCH XS	EES023	
	26	12 - 24			TEE, RED, MSS SP-75, Gr. WPHY 70, BW, SCH XS	EES023	
21	30 - 36	10 - 26			TEE, RED, MSS SP-75, Gr. WPHY 70, BW, RUN SCH 30 x BRANCH SCH XS	EES023	
	34 - 36	30 - 34			TEE, RED, MSS SP-75, Gr. WPHY 70, BW, SCH 30	EES023	
	42	16 - 26			TEE, RED, MSS SP-75, Gr. WPHY 70, BW, RUN SCH TO MATCH PIPE w/ 0.75" WT x BRANCH SCH XS	EES023	
	42	30 -36			TEE, RED, MSS SP-75, Gr. WPHY 70, BW, RUN SCH TO MATCH PIPE w/ 0.75" WT x BRANCH SCH 30	EES023	
	48	22 - 26			TEE, RED, MSS SP-75, Gr. WPHY 70, BW, RUN SCH TO MATCH PIPE w/ 0.875" WT x BRANCH SCH XS	EES023	
	48	30 -36			TEE, RED, MSS SP-75, Gr. WPHY 70, BW, RUN SCH TO MATCH PIPE w/ 0.875" WT x BRANCH SCH 30	EES023	
	48	42			TEE, RED, MSS SP-75, Gr. WPHY 70, BW, RUN SCH TO MATCH PIPE w/ 0.875" WT x BRANCH SCH TO MATCH PIPE w/ 0.75" WT	EES023	
	RUN	**BRANCH**			**FORGED WELD FITTINGS**		
19	8	2 - 3			WELDOLET, MSS SP-97, ASTM A350 LF2 CL 1, RUN SCH STD Gr. B x BRANCH SCH 80 Gr. B		
19	10 - 12	2 - 3			WELDOLET, MSS SP-97, ASTM A350 LF2 CL 1, RUN SCH XS Gr. B x BRANCH SCH 80 Gr. B		
19	16	2 - 3			WELDOLET, MSS SP-97, ASTM A350 LF2 CL 1, RUN SCH XS Gr. X42 x BRANCH SCH 80 Gr. B		
19	18 - 20	2 - 3			WELDOLET, MSS SP-97, ASTM A350 LF2 CL 1, RUN SCH XS Gr. X52 x BRANCH SCH 80 Gr. B		
19	22 - 24	2 - 3			WELDOLET, MSS SP-97, ASTM A350 LF2 CL 1, RUN SCH XS Gr. X60 x BRANCH SCH 80 Gr. B		
19	26	2 - 3			WELDOLET, MSS SP-97, ASTM A350 LF2 CL 1, RUN SCH XS Gr. X70 x BRANCH SCH 80 Gr. B		
19	30 -36	2 - 3			WELDOLET, MSS SP-97, ASTM A350 LF2 CL 1, RUN SCH 30 Gr. X70 x BRANCH SCH 80 Gr. B		
19	42	2 - 3			WELDOLET, MSS SP-97, ASTM A350 LF2 CL 1, RUN 0.75" WT Gr. X70 x BRANCH SCH 80 Gr. B		
19	48	2 - 3			WELDOLET, MSS SP-97, ASTM A350 LF2 CL 1, RUN 0.875" WT Gr. X70 x BRANCH SCH 80 Gr. B		
	2 - 12	1/2 - 1 1/2			SOCKOLET, MSS SP-97, ASTM A350 LF2 CL 1, CL 3000		
	16 - 48	1/2 - 1 1/2			SOCKOLET, MSS SP-97, ASTM A350 LF2 CL 1, CL 6000		
	SIZE RANGE (NPS)				**GASKETS**		
	1/2 - 48				GASKET, SPIRAL WOUND, ASME B16.20, CL 600, RF, 1/8" THK, CS OUTER RINGS, 304 SS INNER RINGS, 304 SS WINDINGS, FLEXIBLE GRAPHITE FILLER		
					BOLTING		
22	1/2 - 48				STUD BOLT w/ 2 HEAVY HEX NUTS, ASTM A320 Gr. L7 / ASTM A194 Gr. 2H		
					VALVES		
	1/2 - 6				TRIPLE OFFSET, LONG PATTERN	EES129/EES110	
	8 - 48				TRIPLE OFFSET, LONG PATTERN	EES110	
	1/2 - 6				TRIPLE OFFSET, SHORT PATTERN	EES129/EES110	
	8 - 48				TRIPLE OFFSET, SHORT PATTERN	EES110	
	1/2 - 6				BALL, TRUNION	EES129	
	1/2 - 6				BALL, FLOATING	EES129	
	1/2 - 6				GATE, WEDGE	EES129	
	1/2 - 6				GATE, SLAB	EES129	
	8 - 48				GATE, COMPACT EXPANDING	EES124	
	8 - 48				GATE, EXPANDING	EES124	
	1/2 - 6				CHECK, DUAL PLATE	EES129	
	8 - 48				CHECK, DUAL PLATE	EES120	
	1/2 - 6				CHECK, SWING	EES129	
	8 - 48				CHECK, SWING	EES120	
	1/2 - 6				PLUG, EXPANDING	EES129/EES122	
	8 - 48				PLUG, EXPANDING	EES122	
	8 - 48				PLUG, 4-WAY	EES122	

Shop and Field Painting: Construction and Maintenance

P-210

Protective Coating Specification

Enbridge Pipelines Inc.
Version Number: 10.0
Version Date: 2018-11-28

Document Version Control Register

1 Revision Summary

Version	Description
10.0	Major revision Reviewed and updated to reflect current industry standards and the Company's best engineering design practices.

2 Applicability

Version	Description	Version Date
10.0	This revision is applicable to all projects that have not received an approved AFE before the effective date of this revision. Projects with an AFE approved before the effective date shall continue to abide by the previous revision. If projects with an approved AFE choose to adopt the latest revision in its entirety, a Project Decision Record is required, clearly noting the standard name, identifier, and version number. For any new revision, engineering consultants shall contact their Enbridge project team for direction on adopting the latest version. Any design changes made by engineering consultants as a result of the latest version without Enbridge project team approval will be at the engineering consultant's risk.	2018-11-28

Note: For a detailed list of changes and approval, see change log (related documents section in the GDL).

Table of Contents

1 Introduction

1.1 Scope

1.1.1 Requirements in Scope

1.1.1.1

This specification defines the Company's requirements for the painting of external surfaces of aboveground parts installed during new construction and for maintenance painting of existing external surfaces of aboveground parts. It covers surface preparation, paint application, inspection, and colour requirements. It covers painting performed in shop, pre-assembly yard, and field environments.

1.1.1.2

The following items are included in the scope of this specification:

a) Aboveground piping and piping components
b) Painting beneath insulation and/or heat trace (including insulated aboveground storage tanks)
c) Pumps (refer to Appendix B for alternative painting options) and fittings
d) Valves (refer to Appendix C for alternative painting options)
e) Control valve and actuators, meters, strainers, and scraper traps (refer to Appendix D for alternative painting options)
f) Structural steel, walkways, platforms, and handrails (refer to Appendix E for alternative painting options)
g) Miscellaneous steel
h) Other items if specified by the Company

1.1.2 Requirements out of Scope

1.1.2.1

This specification does not include requirements for painting of the following:

a) Storage tanks and stairways to tank roofs
b) Galvanized, aluminum, and other non-ferrous metallic surfaces
c) Concrete and other non-metallic surfaces
d) Architectural surfaces such as walls and floors in buildings
e) Firewater systems
f) Surfaces in immersion service
g) Below-grade surfaces
h) Nuts and studs used for flange connections

i) Piles, pile caps, and building skids

1.1.2.2

This specification does not include requirements for the following types of finishes:

a) Paint and other finishes applied by the equipment Manufacturer to items such as but not limited to the following:
   i. Lighting
   ii. Transformers
   iii. Switches
   iv. Electric motors
   v. Sump pumps and sump pump re-injection pumps
   vi. Densitometer pumps
   vii. Compressors
   viii. Actuators and instrumentation
   ix. Electric tank mixers
b) Powder coating
c) Metallic coatings (such as galvanizing)

1.2 Purpose

The purpose of this document is to provide the requirements for the external painting of aboveground surfaces when required for corrosion protection, to meet regulatory requirements, or for safety, identification, or aesthetic reasons.

1.3 Application

1.3.1

This specification shall be used in both Canada and the US for any new and existing facilities where the painting of external surfaces of aboveground parts is required and shall be applied by all defined parties as referenced in this specification.

1.3.2

This document is intended to be read in conjunction with the publications listed in Section 2.

1.4 Responsibility

1.4.1

The Engineer of Record shall be responsible for ensuring the engineering requirements meet applicable federal, provincial, state, and local regulations.

1.4.2

The Project Engineer shall be responsible for ensuring all goods and services are supplied in accordance with the Enbridge Approved Supplier List (EASL).

1.5 Units

1.5.1
The units of measure in this document are presented first in SI units (International System of Units). US customary units (inch-pound units) follow the SI units in parentheses and might not be a direct conversion. Either system of units shall be acceptable for satisfying the requirements of the document. Users of this document should apply one system of units consistently and should not alternate between units.

1.5.2
The values presented for measurements in this document are expressed with a degree of precision appropriate for practical application and enforcement. It is not intended that the application or enforcement of these values be more exact than the precision expressed.

1.5.3
Any measurement value quoted directly from a publication shall be retained without conversion to preserve the integrity of the values established by the author of the source document.

1.6 Deviations
The requirements of this standard shall govern. Any and all deviations from this standard shall be documented and requested in accordance with the Technical Standards Deviation Request procedure or the Technical Standards Noncompliance Management procedure, as required.

2 References

2.1 Company Publications
This document refers to the following publications created by the Company; where such reference is made, it shall be to the latest edition unless otherwise specified.

Engineering & Projects
Guide
ENB-QMS-GUID-017: Inspection and Test Plan (ITP) Preparation Guideline

Engineering Standards
Protective Coating Specification
PCL-ProdList: Approved Product Materials

2.2 Industry Publications
This document refers to the following publications created within industry; where such reference is made, it shall be to the latest edition unless otherwise specified.

ASTM (ASTM International)
D4285
Standard Test Method for Indicating Oil or Water in Compressed Air

D5064
Standard Practice for Conducting a Patch Test to Assess Coating Compatibility

ISO (International Organization for Standardization)
8502-3
Preparation of Steel Substrates before Application of Paint and Related Products – Tests for the Assessment of Surface Cleanliness – Part 3: Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure-Sensitive Tape Method)

12944-2
Paints and Varnishes – Corrosion Protection of Steel Structures by Protective Paint Systems – Part 2: Classification of Environments

NACE (NACE International)
No. 13
Industrial Coating and Lining Application Specialist Qualification and Certification

SP0188
Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates

SP0287
Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape

SSPC (Society for Protective Coatings)
ACS 1
Industrial Coating and Lining Application Specialist Qualification and Certification

Guide 15
Field Methods for Extraction and Analysis of Soluble Salts on Steel and Other Nonporous Substrates

PA 1
Shop, Field, and Maintenance Coating of Metals

PA 2
Procedure for Determining Conformance to Dry Coating Thickness Requirements

PA Guide 5
Guide to Maintenance Coating of Steel Substrates in Atmospheric Service

PA Guide 11
Protecting Edges, Crevices, and Irregular Steel Surfaces by Stripe Coating

SP 1
Solvent Cleaning

SP 2
Hand Tool Cleaning

SP 3
Power Tool Cleaning

SP 6
Commercial Blast Cleaning

SP 7
Brush-off Blast Cleaning

VIS 1
Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

2.3 Abbreviations

The following abbreviations are applicable to this document only:

DFT	Dry film thickness
EASL	Enbridge Approved Supplier List
GDL	Governance Documents Library
ITP	Inspection and test plan
PLM	Pipeline maintenance
QC	Quality control
SDS	Safety datasheet
SME	Subject matter expert
VOC	Volatile organic compound

2.4 Definitions

2.4.1 Technical Definitions

The following definitions are applicable to this document only:

Coating
Liquid material applied to a substrate that adheres to the substrate and hardens in place

Cutback
The area left unpainted adjacent to a weld

Damage
Defects in the applied coating resulting from stresses not associated with coating application and cure (e.g., mechanical impact, weathering)

Paint
Coating material used for aboveground external surfaces

Painting
The application of paint

Part
An individual item that is to be coated under the direction of this specification, such as a pipe, spool, fitting, unit, or component

Sharp edge
An outside edge with an angle of 90° or less that has not been chamfered or rounded to a radius of more than 2 mm (1/16 in.). Refer to SSPC PA Guide 11 for a schematic and additional information.

Stripe coat
A separate coating layer applied prior to the application of a full coat

2.4.2 Defined Parties

The following definitions are applicable to this document only:

Company
The term “Company” shall refer to Enbridge Inc. and its representatives.

Applicator
The term “Applicator” shall refer to the person or company responsible for the application of paint, coating, or lining.

Contractor
The term “Contractor” shall refer to any and all parties who have been contracted to perform work as outlined in this specification.

Engineer of Record
The term “Engineer of Record” shall refer to the professional engineer responsible for the technical design and authentication of the engineering documents.

Inspector
The term “Inspector” shall refer to the Company field or shop representative responsible for performing inspections.

Manufacturer
The term “Manufacturer” shall refer to any and all involved parties that manufacture, supply, and distribute the equipment and products.

Project Engineer
The term “Project Engineer” shall refer to the person or persons responsible for designing or modifying Company facilities. The term includes all Company or contract personnel technically responsible for planned modifications to Company facilities.

2.4.3 Keywords

The following definitions are applicable to this document only:

May
Used to express an option or that which is permissible within the limits of the document

Shall
Used to express a mandatory requirement

Should
Used to express a recommendation or that which is advised but not required

3 General Requirements

3.1 General

Prior to the start of the project, the Company, the Inspector, and the Applicator shall conduct a pre-job meeting to discuss the project requirements, roles, and responsibilities.

Note: The paint Manufacturer's technical representative should also be included in the pre-job meeting to discuss any technical requirements.

3.2 Applicator Responsibilities

The Applicator is responsible for compliance with all requirements of this specification except where otherwise specified or approved in accordance with the Technical Standards Deviation Request procedure.

3.3 Resourcing

The Applicator shall supply all resources, including but not limited to materials, consumables, labour, equipment, scaffolding, and transportation, needed to complete the work according to the agreed-upon project schedule except where otherwise specified or agreed.

3.4 Manufacturer's Recommendations

Where there is a conflict between the Manufacturer's written instructions and recommendations and the content of this document, the most stringent requirement shall apply.

3.5 Conflicting Requirements

Conflicting requirements from Company specifications shall be brought to the attention of the Company for resolution. In the absence of a resolution, the more stringent requirement shall prevail.

3.6 Applicator Approval

The Applicator shall be approved by the Company in accordance with its procurement procedures and listed on the Enbridge Approved Supplier List (EASL).

3.7 Competency of Personnel

The Applicator shall provide personnel who are appropriately qualified, trained, and experienced to perform their assigned duties. If requested by the Company, the Applicator shall submit documentation to demonstrate the competency of its personnel.

Note: Applicators should be certified in accordance with SSPC ACS 1/NACE No. 13 at the level appropriate to their assigned duties.

3.8 Scheduling

3.8.1
Work shall be planned, scheduled, and sequenced to ensure that surfaces that would be difficult or impossible to paint after a particular stage of assembly are painted prior to that stage.

3.8.2
All parts shall be primed and top-coated prior to final site assembly. Field welds and damaged coating shall be painted after final site assembly.

3.9 Company Right to Review and Stop Work

3.9.1
The Company shall have the right to review and inspect the Applicator's work at any time.

3.9.2
The Company reserves the right to stop any or all work at any time for non-compliance with the stated requirements of this specification, during emergency situations, or for other justifiable reasons.

4 Materials

4.1 Paint Material Selection

4.1.1
Approved paint systems for P-210 are listed in PCL-ProdList.

4.1.2
The Company shall select and specify the paint system number to use for each part to be painted.

Note: This specification does not provide guidelines for the design or selection of paint systems. The material, item type, operating conditions, and environment usually determine the paint system to use. Identification information (such as the PCL-ProdList system number) for selected paint systems should be indicated by the Company for each item to be painted (e.g., in the project specification, drawings, or purchase order).

4.2 Compatibility with Existing Paint

4.2.1
When overcoating existing paint during maintenance activities, where the previously applied paint is not completely removed (Condition B), the Applicator is responsible for selecting and using paint that is compatible with the existing paint.

4.2.2

The Manufacturer should be consulted for advice regarding the compatibility of its products with the existing paint.

4.2.3

If necessary, the Company shall provide access to the Applicator or Manufacturer to carry out compatibility patch tests prior to the commencement of work. If required, the Applicator shall perform the compatibility patch test in accordance with ASTM D5064.

4.2.4

The Applicator shall be held responsible for the rectification of defects caused by the application of incompatible coatings.

4.2.5

When overcoating existing paint, the systems and products listed in PCL-ProdList shall be used only as guidelines. If the paint products listed in PCL-ProdList are not compatible with the existing paint, alternative systems and products that are compatible may be used subject to the approval of this document’s SME as listed in the GDL.

4.3 Single Manufacturer

For new construction, paint materials used together in a paint system shall be from the same Manufacturer.

4.4 Paint Colour

The finish coat colour shall be as specified by the Company.

Note: Appendix A provides the Company’s recommended colour scheme. Appendix A should be followed unless in conflict with local practices. The Company may also request colour matching to ensure consistent colouring at Company sites.

4.5 Delivery, Handling, and Storage of Materials

4.5.1

The Applicator shall be responsible for the delivery, handling, and storage of materials used in the work.

4.5.2

Paint materials shall be delivered and stored in the original sealed and undamaged containers bearing the Manufacturer’s name, product identification, batch numbers, and expiry date.

4.5.3

Paint materials shall be pre-mixed to the required colour by the Manufacturer prior to delivery to the work site. The Applicator shall not tint any materials.

4.5.4
Containers of paint or components shall not be opened unless for immediate use.

4.5.5
Paint materials shall be stored in a secure, clean, dry, well-ventilated, shaded area protected from sparks, flame, and extremes of heat or cold and in accordance with the Manufacturer's latest published instructions. Adequate and suitable storage facilities shall be provided by the Applicator. Storage conditions shall meet the Manufacturer's recommendations.

4.5.6
Paint materials shall not be used after the expiry of the Manufacturer's shelf life for the product.

4.5.7
The Applicator shall keep accurate records of materials used in the work. At minimum, these records shall include product names, batch numbers, expiry dates, and quantities. These records shall be shall be submitted with the quality control documentation for the project.

4.5.8
The Applicator shall confirm that the batch numbers on the containers match the batch numbers on the shipping documentation from the Manufacturer. If the batch numbers do not match, the Applicator shall quarantine the materials and notify the Manufacturer for resolution.

4.6 Abrasive Blast Media

4.6.1
A list of abrasives approved by the Company is located in PCL-ProdList.

4.6.2
Abrasive blast media shall be dry, shall have a pH consistent with the SDS, and shall contain no contaminants that may be injurious to the performance of the applied paint. Examples of contaminants include salt, high clay content, oil, moisture, and residual metals (e.g., copper in copper slags).

4.6.3
The abrasive blast medium used shall comply with regulations governing the use of abrasive blast materials and with health and environmental restrictions in effect at the work site.

4.6.4
The abrasive blast medium used shall be capable of producing an angular anchor pattern and the required anchor profile.

4.6.5
Recycled blast media may be used only where automated dust removal equipment is functioning and procedures for maintaining the working mix and monitoring the abrasive contamination levels have been approved by the Company.

4.6.6
When steel grit and shot abrasive is used, the working mix shall comply with the equipment Manufacturer's recommendations. Routine and frequent addition of grit to the grit/shot mixture is required to achieve a dense, angular profile of the specified depth.

Note: High steel shot abrasive may produce a peen surface blast profile. Peened surface blast profiles shall be rejected by the Inspector.

5 Surface Preparation

5.1 Surface Condition

5.1.1
Surfaces to be painted shall be identified as being in either Condition A or Condition B as follows:

a) Surfaces to be abrasive blasted to bare steel shall be identified as Condition A.
b) Previously painted surfaces to be overcoated without complete removal of the existing paint shall be identified as Condition B.

5.1.2
The condition of each surface to be painted shall be assessed and identified by the Company to be either A or B. The Applicator may conduct its own condition assessment during a site visit prior to bidding. The Applicator and the Company shall agree on the condition of each surface to be painted prior to bidding. The agreed-upon condition of each surface to be painted shall be indicated in bid documentation.

5.1.3
The following guidelines should be used when assessing the condition of a surface:

a) Condition A surfaces are areas to be abrasive blasted to bare steel, including the following:
    i. New construction, unpainted steel
    ii. Previously painted surfaces that cannot be top-coated effectively and must be prepared to bare steel to ensure acceptable paint integrity (e.g., extensively weathered, blistered, stained, rusted, non-adherent, or overly thick paint)
    iii. Maintenance activates that require the removal of the existing paint system (e.g., nondestructive examination)
b) Condition B surfaces are areas to be high pressure water washed or abraded to provide surface roughness but not to remove existing paint, including previously painted surfaces that can be refurbished by overcoating the existing paint. The existing paint shall be well adhered and have a generally good appearance (some primer may show).

Note: SSPC PA Guide 5 provides additional guidelines related to maintenance painting.

5.1.4

For maintenance activities, items to be painted may display both Condition A and Condition B surfaces.

5.2 Damaged Steel

Prior to the commencement of surface preparation, parts shall be visually inspected. Damage (such as dents, gouges, and corrosion pits) shall be noted, and the Company shall be notified of the location, extent, and cause of damage. Damaged steel on piping and pressure vessels shall not be blasted or coated until authorization has been given by the Company.

5.3 Pre-Preparation

Surfaces shall be inspected prior to abrasive blasting to confirm that imperfections in the steel that could compromise the performance of the paint are not present. These imperfections include but are not limited to laminations, slivers, rough welds, weld slag, weld spatter, and sharp edges. Imperfections in the steel and non-compliant edge or weld preparation shall be reported to the Inspector for resolution. A radius on sharp edges should be obtained using grinding (refer to SSPC PA Guide 11). Until the imperfections have been resolved, paint shall not be applied to these areas.

5.4 Preparation of Condition A Surfaces

5.4.1

All Condition A surfaces to be painted shall be abrasive blast cleaned.

5.4.2 Pre-Cleaning

The steel surface shall be examined for visible contaminants such as dirt, oil, and grease. If present, these contaminants shall be removed prior to blast cleaning in accordance with SSPC SP 1 using suitable water-based cleaning agents or organic solvents. Cleaning agent residues shall be removed by rinsing the surface.

5.4.3 Blast Cleanliness

The part shall be abrasive blasted to achieve the standard of cleanliness specified by the Company for the paint system to be applied. The Applicator shall ensure this standard of cleanliness is attained by regular comparisons against SSPC VIS 1.

5.4.4 Blast Profile

5.4.4.1

The average abrasive blast profile shall be in the range specified for the applicable paint system as shown in PCL-ProdList. Individual readings shall be within the range of 25 – 89 μm (1 – 3.5 mil).

5.4.4.2

5.4.4.3
Profile measurements shall be taken with replica tape and a micrometer in accordance with NACE SP0287.

Note: The replica tape does not need to be provided in the turnover document. The replica tape shall be available to the Inspector for review.

5.4.4.4
A set of profile measurements shall be taken at minimum at the start and end of the workday, and, if using recycled abrasive media, at least once per cumulative hour of blasting. A set of profile measurements shall consist of a minimum of three replica tape measurements at different locations on the part measured.

5.4.5 Rust Bloom

5.4.5.1
Prepared surfaces shall be primed the same day they were blasted unless continuous environmental controls are in place to maintain the condition of the surface within the requirements.

5.4.5.2
Paint shall be applied before visible oxidation (flash rusting) occurs. Flash rust shall be removed by reblasting.

5.5 Preparation of Condition B Surfaces

5.5.1
All Condition B surfaces shall be cleaned in accordance with SSPC SP 1 to remove any accumulations of deleterious contaminants such as grease, oil, dirt, salt, and chalking from the original paint using cleaning agents approved by the Manufacturer. A high pressure water wash 34 – 70 MPa (5,000 – 10,000 psi) hot water jet shall be used as the final cleaning measure and to prepare the surface for overcoating.

5.5.2
The cleanliness of the surface shall be tested by rubbing the surface with a dry black rag. The surface shall be considered clean from chalk when the rag can no longer be discoloured white.

5.5.3
Once all surfaces have been cleaned, any spots where the high pressure water wash has removed the paint down to the bare steel shall then be prepared in accordance with Condition A requirements.

5.5.4
The painted surfaces require surface roughening to ensure adhesion of the new paint. At minimum, an SSPC SP 7 blast shall be completed prior to overcoating.

5.6 Cutbacks

Cutbacks (pipe ends that will be welded) shall be abrasive blast cleaned. Coating shall not be applied to cutbacks prior to welding. The cutback length shall be approximately 15 cm (6 in.) from the bevelled edge if not directly specified by the Company (e.g., in the purchase order).

5.7 Blotter Test

5.7.1 General

Clean, dry compressed air shall be used for abrasive blasting. Air lines originating at compressor units shall have adequate separators, filters, and drains to ensure contaminants such as oil and water are not deposited onto the steel surface. Accumulations of oil and moisture shall be removed by regular purging.

5.7.2 Criteria

There shall be no contaminants in the air lines originating at the compressor units.

5.7.3 Method

A blotter test is performed by directing air onto a clean white absorbent surface (e.g., blotter or filter paper) per ASTM D4285.

Note: The blotter or filter paper does not need to be provided in the turnover document. The blotter or filter paper shall be available to the Inspector for review.

5.7.4 Frequency

The cleanliness of the compressed air used for blasting shall be tested at the start of the workday and whenever a mechanical breakdown occurs on the abrasive blast units.

5.7.5 Failed Test

An abrasive blasting unit that displays oil or water residue transfer shall be removed from service until the unit can display a clean test result.

5.8 Dust Removal

5.8.1 General

After abrasive blasting of the surface has been completed, dust and debris shall be removed from abrasive blast-cleaned surfaces using clean, dry compressed air or a vacuum.

5.8.2 Criteria

At the time of coating application, the dust level on the exposed steel surface being coated shall meet the requirements of ISO 8502-3 Class 2, and the measurements shall be recorded in the coating report.

Note: The tape does not need to be provided in the turnover document. The tape shall be available to the Inspector for review.

5.8.3 Test Method
Dust levels shall be measured using ISO 8502-3.

Note: The spring-loaded roller requirement in ISO 8502-3 is not required by the Company.

5.8.4 Frequency
The dust level shall be measured and recorded at three different locations per ISO 8502-3 prior to application of the primer. At minimum, the dust levels shall be tested once per day prior to primer application.

5.9 Salt Testing

5.9.1
If at least one of the following conditions is met, soluble salt levels shall be measured on each lot, shipment, or shift using a method described in SSPC Guide 15:

a) It is suspected that the steel is contaminated with salt.
b) The steel surface is pitted.
c) White deposits are visible on the surface.
d) The steel has been exposed to industrial or coastal atmospheres or road salts.
e) Measurement has been requested by the Inspector.
f) Paint is under insulation and/or heat trace.

5.9.2
Salt levels shall be tested and recorded in the coating report at a frequency of at least one per 50 joints/parts or one per 100 m^2 (1,076 ft^2) but not exceeding a total of 15 salt tests per day. For Systems 1 and 2 in PCL-ProdList, the acceptable salt levels shall be chlorides < 20 $\mu g/cm^2$ or total soluble salts < 50 $\mu g/cm^2$. For Systems 3 and 4 in PCL-ProdList, the acceptable salt levels for paint under insulation and/or heat trace shall be chlorides < 2 $\mu g/cm^2$ or total soluble salts < 7 $\mu g/cm^2$.

5.9.3
Salt contamination exceeding acceptable levels shall be removed prior to abrasive blast cleaning by cleaning with pressured hot water wash, 17 – 34 MPa (2,500 – 5,000 psi), or a water-based salt removal solution. The surface shall be retested for soluble salt levels after cleaning and the results recorded as post-cleaning in the coating report.

5.10 Temporary Protection

5.10.1
Temporary shielding shall be used where necessary during surface preparation to prevent damage to adjoining or adjacent surfaces (or equipment) from abrasives, water, dust, or water.

5.10.2
Blast media, dust, paint, and water shall be prevented from entering the internals of equipment. Such equipment includes but is not limited to valves, fittings, pipe, and rotating equipment.

5.10.3
Certain materials, surfaces, and equipment types shall not be blasted or painted and shall be protected from damage during surface preparation and painting. Such materials, surfaces, and equipment include but are not limited to the following:

a) Non-carbon steel materials such as stainless steel, aluminum, plastic, and fibreglass surfaces
b) Machined surfaces and moving or sliding mechanisms such as valve stems, lubrication fittings, operating shafts, linkages, and threads
c) Raised faces of flanges and other gasket surfaces Glass such as that used for instrument cages, level gauges, lighting fixtures, and building windows
d) Information and identification labels such as nameplates, name tags, instrument dials, and caution and warning signs
e) Galvanized, painted, or coated surface finishes
f) Electrical panels and electrical conductors
g) Removable fasteners
h) Cutbacks (protected from painting in a shop)

5.10.4
The Applicator shall be responsible for consulting with the Company to clearly identify which surfaces are to be painted and to clearly delineate them from surfaces not to be painted.

5.10.5
Blast cleaning and dust removal shall be performed in a manner that prevents abrasive dust from contaminating adjacent wet paint and other sensitive surfaces.

5.10.6
Suitable masking materials shall be used if necessary to prevent paint from coming into contact with surfaces that are not to be painted. Masking materials shall be removed after completion of painting.

6 Paint Application

6.1 Environmental Conditions

6.1.1
Environmental conditions shall be monitored. Paint shall only be applied within the environmental conditions allowed by the Manufacturer's datasheets.

6.1.2

The ambient dew point, relative humidity, and air temperature shall be measured and recorded at the start of daily painting activities, when weather conditions change, and at least once every 4 h during painting activities.

6.1.3

Paint shall not be applied in the following environmental conditions:

a) The substrate temperature is outside the Manufacturer's recommended temperature limits.
b) The substrate temperature is less than 3°C (5°F) above the air dew point temperature, or the substrate is expected to fall below the dew point before the paint has cured (unless allowed by the Manufacturer's published instructions).
c) There is rain, snow, or fog, or surfaces are wet or covered with ice.
d) There are strong winds that exceed 39 km/h (24 mph), particularly for spray application.
e) Insects or dust will contaminate the finish.

6.1.4

Painted surfaces damaged by adverse environmental conditions (e.g., rain) during application or cure shall be replaced by the Applicator.

6.2 Application Instructions

Paint shall be applied in accordance with SSPC PA 1, the paint Manufacturer's published instructions, and the Company's requirements.

6.3 Thinning

If it is necessary to reduce the viscosity of the paint by adding solvents, thinning shall be done in accordance with the Manufacturer's specifications and shall not exceed the VOC level allowed by local regulations. Paint shall not be thinned in excess of 340 g/L (2.8 lb/gal) VOC.

Note: The viscosity of the paint should be controlled by controlling its temperature in accordance with the Manufacturer's published instructions (e.g., by using in-line heaters).

6.4 Mixing and Handling

6.4.1

Mixing equipment, procedures, product temperatures, induction period (if applicable), and other handling shall be in accordance with the Manufacturer's recommendations.

6.4.2

If induction time is required after mixing, the Applicator shall record in the coating report: the mix time, the observed induction time, and the time application began for each kit mixed.

6.4.3

Paint that has exceeded its pot life shall not be applied; it shall be discarded and the equipment cleaned.

6.4.4

If required by the Manufacturer, materials that have a tendency to settle rapidly, such as zinc-pigmented paints, shall be continuously agitated during application.

6.5 Spray Application

Paint shall be applied by spray in accordance with the Manufacturer's published instructions.

6.6 Roller and Brush Application

Where spray application is not practicable, alternative application methods (e.g., roller or brush) may be used. Roller or brush application is acceptable for small repairs. Rollers and brushes used for application shall be of a style and quality that enables proper application of paint.

6.7 Stripe Coating

Bolt heads, nuts, exposed threads, crevices, holes, welds, rough areas, and sharp edges shall be stripe coated with primer using a brush.

Note: Refer to SSPC PA Guide 11 for additional information regarding stripe coating.

6.8 Caulking

Gaps, holes, or crevices that cannot be adequately painted shall be filled with a Company-approved sealant (caulking) after stripe coating.

6.9 Cutbacks and Welds

No paint shall be applied within 10 cm (4 in.) of areas to be welded.

6.10 Film Thickness

The dry film thickness shall be as specified in PCL-ProdList.

6.11 Application of Paint System

6.11.1

Each coat (i.e., primer, intermediate, if required, and top coat) shall be allowed to cure before application of the next coat in accordance with the Manufacturer's published instructions (i.e., overcoating schedule/recoat window). Surface temperatures and air humidity shall be monitored and recorded in the coating report during the curing period as outlined in Section 6.1 of this specification.

6.11.2

Prior to the application of the next coat, coated surfaces shall be visually examined for contaminated or defective areas by the Applicator. Contamination and defective areas shall be removed and repaired, and the surface shall be prepared and repainted.

6.11.3
Overcoating shall be performed within the time allowed by the Manufacturer's recoat window or within 30 days, whichever is more stringent. The Company shall be notified if the recoat window is exceeded and, if approved by the Project Engineer, the Manufacturer's published remedial instructions shall be followed and recorded in the coating report.

6.12 Cure
The Manufacturer's required temperature and ambient conditions shall be maintained consistently throughout the application and cure period until the coating is sufficiently cured for inspection and handling.

6.13 Appearance

6.13.1
Finished coating shall be continuous film with a smooth, uniform appearance that is free of defects.

6.13.2
Unacceptable defects include but are not limited to bare spots, visible holidays, visible pinholes, runs, sags, blisters, dry spray, blushing, crazing, cracking, fish eyes, bubbling, or other blemishes.

7 Touch-up and Repair

7.1 General
Paint defects and damage (caused by improper application, shipping, handling, cutting, welding, or other causes) shall be reported, rectified, and recorded in the coating report by the Applicator prior to the release of the parts to the Company.

7.2 Inadequate Thickness
Areas with inadequate coating thickness shall be rectified by applying an additional coat in accordance with this specification.

7.3 Deleterious Embedments
Any paint bristles, insects, dirt, or foreign particles embedded in the coating shall be removed. The affected area shall be rectified in accordance with this specification.

7.4 Paint Damage Not Exposing Steel
Paint damage not exposing steel shall be rectified as follows:

a) Contamination shall be cleaned in accordance with SSPC SP 1.

b) The damage or defect shall be removed, and adjoining edges of paint shall be feathered according to SSPC SP 2 or SSPC SP 3.

c) Residuals shall be cleaned with compressed air, dry rags, or Manufacturer-approved solvent.

d) Additional coats shall be applied in accordance with this specification.

e) All abraded areas shall be painted over, and the topcoat shall have a final finish that is smooth, uniform, and blended in.

7.5 Paint Damage Exposing Steel

Paint damage exposing steel shall be rectified as follows:

a) Contamination shall be cleaned in accordance with SSPC SP 1.

b) Exposed areas of steel less than 232 cm^2 (36 in^2) shall be abraded according to SSPC SP 2 or SSPC SP 3 or as the Manufacturer requires.

c) Exposed areas greater than or equal to 232 cm^2 (36 in^2) shall be abrasive blasted in accordance with this specification.

d) Adjoining edges of acceptable paint shall be feathered.

e) Primer and topcoat may be brush applied for areas ≤ 232 cm^2 (36 in^2).

f) Primer and topcoat should be spray applied for areas > 232 cm^2 (36 in^2).

g) All abraded areas shall be painted over, and the final finish shall be smooth, uniform, and blended in.

7.6 Other Defects

Defects in the applied paint, excluding those addressed above but including areas of excessive thickness, shall be completely removed and replaced in accordance with this specification. All abraded areas shall be painted over, and the final finish shall be smooth, uniform, and blended in.

8 Transportation and Handling

8.1 Painted Parts

8.1.1

Parts shall be handled and stored in a manner that prevents damage to the part and to the painted surface.

8.1.2

To prevent damage, applied paint shall be allowed sufficient time to cure prior to handling.

8.1.3

Painted surfaces shall be protected from damage during storage, shipping, and handling.

Note: Dunnage, softeners, padding, traps, and non-metallic slings should be used. It is important to ensure surfaces in contact with parts during handling and transportation are free from debris and metallic objects such as nail heads that could damage the paint.

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9 Quality Control

9.1 QC Responsibility

9.1.1

The Applicator shall be responsible for quality control of the work.

9.1.2

Applicator personnel responsible for performing QC inspections shall be certified at minimum to NACE CIP Level 2 or SSPC PCI Level 2.

9.2 Inspection and Test Plan (ITP)

9.2.1

Prior to the commencement of painting work, the Applicator shall prepare and submit an ITP to the Company for its acceptance. Inspection shall be performed as required by this specification and as indicated in the accepted ITP.

Note: Refer to ENB-QMS-GUID-017 for ITP preparation guidelines.

9.2.2

The ITP shall include but not be limited to the following information:

a) Project name

b) Applicator

c) Equipment or items to be painted

d) Reference to this specification

e) Paint systems to be applied

f) Finish colours

g) Tests and inspections activities as listed below

h) Test frequency

i) Acceptance criteria

j) Specified standards or test methods

k) Test instrument

l) Inspection criteria for the Applicator and the Company; R, V, W, and H as defined in ENB-QMS-GUID-017

9.2.3

As a minimum, the following R, V, W, and H inspection activities and tests (ENB-QMS-GUID-017) shall be included in the ITP for sign off by the Inspector:

a) Contractor ITP approved (H)
b) Company-approved Applicator (H)
c) Applicator’s QC inspector meets competency requirements of this specification (R)
d) Paint materials listed in PCL-ProdList (R)
e) Paint materials selected according to the system number listed in the issued-for-construction drawing, the as-built drawing, or the engineer design notice, if applicable (R)
f) Substitution or deviation (material grade and type) approved by the Company (H)
g) Shipping and material receiving information complies with Company specifications (R)
h) Surface preparation performed per SSPC SP 1 (W)
i) Blotter test performed per ASTM D4285 (R)
j) Abrasive materials listed in PCL-ProdList (R)
k) Salt test performed per SSPC Guide 15 (R)
l) Surface profiles measured per NACE SP0287 (R)
m) Dust test performed per ISO 8502-3 (R)
n) Prepared surfaces are acceptable for painting (H)
o) Environmental conditions (R)
p) Stripe coating (R)
q) Primer coat application visual inspection and DFT measurements performed per SSPC PA 2 (H)
r) Intermediate coat application visual inspection and DFT measurements (if applicable based on paint selection) performed per SSPC PA 2 (H)
s) Top coat application visual inspection and DFT measurements (if applicable based on paint selection) performed per SSPC PA 2 (H)
t) Holiday detection performed per NACE SP0188 (W)
u) Final coating inspection and release (H)
v) Final turnover of documentation reviewed (H)
w) Documentation reviewed and accepted by all parties; Contractor turnover transmittal (H)

9.2.4

If required, the Company shall have the right to increase the R, V, and W inspection activities and tests listed in Section 0.

9.3 Holiday Testing

9.3.1 Paint under Insulation

Painted surfaces that will be in service under insulation shall be inspected using low voltage (50 – 120 V wet sponge) holiday detection in accordance with NACE SP0188.

Note: 100% of the surface shall be holiday tested if the part is insulated and/or heat traced.

9.3.2 Other Surfaces

Low voltage holiday detection may be performed on other surfaces.

Note: The Inspector may, at its discretion, choose to perform holiday testing when the quality of the work is visibly in question. Holiday testing is an inspection method and is not intended to be executed over 100% of the surface.

9.3.3 Irregular Shapes

Brass brush electrodes or low voltage wet sponge holiday detectors may be used for areas that are difficult to access due to their irregular shapes (such as nuts, bolts, and corrosion pits).

9.3.4 Holiday Repairs

Holidays shall be marked and repaired in accordance with Section 7.5 of this specification.

9.4 Thickness Measurement

The dry film thickness of each coat shall be measured and recorded in accordance with SSPC PA 2 using restriction level 3. Special attention shall be given to complex or hard-to-coat areas. Areas with non-compliant dry film thickness shall be identified, marked, and rectified. The calibration of instruments shall be verified with an appropriate standard within ±20% of the DFT range.

9.5 Calibration

Measurement equipment shall be calibrated within 12 months. Equipment used to perform quality control measurements shall have current calibration certificates. Copies of these certificates shall be available to the Company on request.

9.6 Non-Compliant Areas

Non-compliant areas shall be identified, marked for repair, rectified, documented, and recorded in the coating report by the Applicator prior to the release of the parts to the Company.

9.7 Inspection by Company

9.7.1

Company-performed inspections and tests shall not relieve the Applicator of its responsibility to perform quality control.

9.7.2
The Company shall have the right to witness the Applicator's activities, review its documentation, inspect the work, and perform tests to verify quality.

9.7.3
The Company shall have the right to reject work that does not conform to this specification. Acceptance of the work by the Inspector shall not relieve the Applicator of the responsibility for compliance with this specification or the performance of the coating after it has been released to the Company.

9.7.4
The Applicator shall provide the Inspector with at least three business days' notice of inspection. Notice shall be provided and confirmed in verbal and written communication. The Company shall make reasonable efforts to accommodate the Applicator's schedule to avoid delays. Hold point notification arrangements should be agreed between parties at the pre-job meeting. The coating Inspector or QC representative should always be involved in the pre-job meeting when discussing hold point arrangements.

9.8 Performance Warranty
The Applicator shall rectify defects in the coatings it applied that become apparent prior to or during the 12-month period commencing on the date the painted parts were released to and accepted by the Company if such defects result from issues during paint manufacture, surface preparation, paint application, or cure. Such defects include but are not limited to rusting, disbondment, cracking, blistering, flaking, and changes in colour. Defects do not include damage to the coating caused by exposure of the coating to conditions for which it was not designed (such as excessive force or temperature).

9.9 Quality Control Records

9.9.1
The Applicator shall produce accurate painting records of all painting materials, preparation, application, test measurements, and inspection activities.

9.9.2
The painting records shall include at least the following information:

a) Identification:
   i. Project name
   ii. Part identifier (description, number/location)
   iii. Drawing number, if applicable
   iv. Drawing component identifier (e.g., tag number or drawing item number), if applicable

   v. Applicator's company name
   vi. Applicator
   vii. Inspector
   viii. Inspection date
b) Surface preparation for Condition A:
   i. Date and time of abrasive blast
   ii. Salt test method and result, if applicable
   iii. Substrate temperature
   iv. Ambient temperature (°C/°F)
   v. Dew point temperature (°C/°F)
   vi. Name, type, and size of abrasive
   vii. Surface cleanliness (SSPC SP 6, etc.)
   viii. Anchor profile depth
   ix. Dust test
   x. Compressed air quality (blotter test) result
c) Surface preparation for Condition B:
   i. Date and time of high pressure water wash
   ii. Salt test method and result, if applicable
   iii. Name, type, and size of abrasive
   iv. Surface cleanliness (SSPC SP 7, etc.)
   v. Dust test
   vi. Compressed air quality (blotter test) result
d) Paint application:
   i. Date and time of each coat applied
   ii. Name, batch number, and expiry date of products
   iii. Induction time, if applicable
   iv. Substrate temperature
   v. Ambient temperature (°C/°F)
   vi. Dew point temperature (°C/°F)
e) Inspection:
   i. Dry film thickness for each coat
   ii. Holiday test voltage and results, if application
   iii. Painting repairs
   iv. Verification and adjustment of calibrated equipment

v. Comments

9.9.3

The Applicator's QC records and reports shall be available for review by the Company at all times during working hours, and QC reports shall be submitted to the Company prior to the final coating inspection release.

9.9.4

All required quality documentation, including all test results and measurements required by the ITP, shall be forwarded to the Company within the agreed timeline for the project records turnover, but no later than 14 calendar days.

Appendix A
Colour Table

Table A.1 – Colour Table

Colour	Items Painted
White (RAL 9003)	• All outside exposed piping, valves, and sump pumps • Overhead structural racks • Light pole stands • Right-of-way post tops • Meter provers
Black (RAL 9005)	• All tank and manifold valve handwheels[1] • Platform decking (non-galvanized) • Loading dock • Chain block and trolleys • Manifold valves • Transfer line valves
Grey (RAL 7045)	• Checker plate floors in skid-mounted metal shelters (grit may be added for slip resistance)
Fire red (RAL 3020)	• Fire boxes and fire lines on tanks • Hydrants
Safety yellow (RAL 1023)	• All handrails (except tankage) • Portable gantries
Safety orange (RAL 2009)	• Edmonton PLM shop tools • Right-of-way signs and posts
Purple (RAL 4008)	• Abandoned or out-of-service mainline valve handwheels[2]

Notes:

1. Enbridge Energy Partners LP projects should follow local practices when in conflict with the above colour chart. Request Company colours when ordering paint from the approved supplier list.
2. The entire handwheel of pipeline valves, including spokes, shall be painted the appropriate colour. If there is no handwheel, the hydraulic operators shall be painted.
3. For deactivated valves on a pipeline, handwheels shall be painted one-half purple as well as one-half in the line colour code. Where applicable, valve stem weather caps may also be painted the appropriate colour.

Appendix B
P-210 Exceptions for Pumps
Content Owner: Operations Engineering – Mechanical

B.1 Mainline, Booster, and Other Pumps (EES015 and EES027)

B.1.1 Scope

This appendix documents an alternative paint process instead of P-210 for mainline, booster, and other pumps.

B.1.2 General Requirements

The pumps (mainline, booster, and other pumps) may be painted in accordance with the pump Manufacturer's paint procedures.

B.1.3 Paint Selection

B.1.3.1

Paint selection for uninsulated pumps shall be based on the Manufacturer's recommendations for a high durability (> 15 years) coating system based on the ISO 12944-2 atmospheric corrosivity category for the asset, and the selected products shall be approved by the Company.

Note: The pump Manufacturer shall provide a letter of conformance from the paint Manufacturer. This letter shall state the surface profile range required for the paint system and shall indicate that the paint system (product names and DFT ranges) is rated for high durability for the identified ISO 12944-2 atmospheric corrosivity category for the asset.

B.1.3.2

Surface profiles, DFT, and paint systems for heat-traced and/or insulated pumps shall be selected from the options given for "Painting under Insulation" in PCL-ProdList for P-210. After installation and prior to heat trace and insulation, the pump shall be inspected (DFTs verified) and holiday tested in the field by an Inspector (minimum NACE CIP Level 2) to ensure an intact coating.

B.1.3.3 Mainline Pumps

Unless otherwise indicated in the purchase order, the paint colour for mainline pumps will be as follows:

a) Canada: Pump Green (RAL 6018)

b) US: Pump Grey (FED 26373)

c) North Dakota: Pump White (RAL 9016)

B.1.3.4 Booster Pumps

Unless otherwise indicated in the purchase order, the paint colour for booster pumps will be Pump White (RAL 9016).

B.1.4 Surveillance

Company surveillance shall consist of a document review to ensure compliance to this appendix. The document review does not require a NACE CIP Inspector.

Appendix C
P-210 Exceptions for Valves
Content Owner: Operations Engineering – Mechanical

C.1 Large-Bore Valves NPS 8 and Larger (EES110, EES120, EES122, EES124, and EES136) and Small-Bore Valves NPS 6 and Smaller (EES129) in Main Process Flow – All Types

C.1.1 Scope

This appendix documents an alternative paint process instead of P-210 for all large-bore valves (NPS 8 and larger) and small-bore valves (NPS 6 and smaller) in main process flow applications.

C.1.2 General Requirements

C.1.2.1

Main process flow and auxiliary valves NPS 8 and larger may be painted in accordance with the valve Manufacturer's paint procedures.

C.1.2.2

Painting shall be performed after the valve has passed the hydrostatic shell and seat pressure tests.

C.1.3 Paint Selection

C.1.3.1

Paint selection for uninsulated valves shall be based on the Manufacturer's recommendations for a high durability (> 15 years) coating system based on the ISO 12944-2 atmospheric corrosivity category for the asset, and the selected products shall be approved by the Company.

Notes: The valve Manufacturer shall provide a letter of conformance from the paint Manufacturer. This letter shall state the surface profile range required for the paint system and shall indicate that the paint system (product names and DFT ranges) is rated for high durability for the identified ISO 12944-2 atmospheric corrosivity category for the asset.

C.1.3.2

Surface profiles, DFT, and paint systems for heat-traced and/or insulated valves shall be selected from the options given for "Painting under Insulation" in PCL-ProdList for P-210. After installation and prior to heat trace and insulation, the valves shall be inspected (DFTs verified) and holiday tested in the field by an Inspector (minimum NACE CIP Level 2) to ensure an intact coating.

C.1.3.3

Paint colour shall be as specified in Table A.1.

C.1.4 Surveillance

Company surveillance shall consist of a document review to ensure compliance to this appendix. The document review does not require a NACE CIP Inspector.

C.2 Auxiliary Valves NPS 6 and Smaller (EES129) – All Types

C.2.1 Scope

This appendix documents an alternative paint process instead of P-210 for small-bore valves (NPS 6 and smaller) in auxiliary applications.

C.2.2 General Requirements

C.2.2.1

The small-bore valves (NPS 6 and smaller) in auxiliary applications may be painted in accordance with the valve Manufacturer's paint procedures.

C.2.2.2

Painting shall be performed after the valve has passed the hydrostatic shell and seat pressure tests.

C.2.3 Paint Selection

C.2.3.1

Paint selection for uninsulated valves shall be based on the Manufacturer's recommendations for a high durability (> 15 years) coating system based on the ISO 12944-2 atmospheric corrosivity category for the asset, and the selected products shall be approved by the Company.

C.2.3.2

Surface profiles, DFT, and paint systems for heat-traced and/or insulated valves shall be selected from the options given for "Painting under Insulation" in PCL-ProdList for P-210. After installation and prior to heat trace and insulation, the valves shall be inspected (DFTs verified) and holiday tested in the field by an Inspector (minimum NACE CIP Level 2) to ensure an intact coating.

C.2.4 Surveillance

Company surveillance is not required.

Appendix D
P-210 Exceptions for Other Manufacturer Parts
Content Owner: Operations Engineering – Mechanical

D.1 Control Valve and Electro-Hydraulic Actuator (EES006A), Electric Valve Actuator (EES010), Fast Loop Electric Actuator (EES151), Meter Bidirectional Provers (EES003), Positive Displacement Meters for Custody Transfer (EES016), Strainers (EES134), Scraper Traps (EES116), Turbine Meters for Custody Transfer (EES041), and Ultrasonic Flowmeters (EES119)

D.1.1 Scope

This appendix documents an alternative paint process instead of P-210 for actuators, meters, provers, strainers, and traps.

D.1.2 General Requirements

The actuators, meters, provers, strainers, and traps may be painted in accordance with the actuator, meter, prover, strainer, and trap Manufacturer's paint procedures.

D.1.3 Paint Selection

D.1.3.1

Paint selection for uninsulated actuators, meters, provers, strainers, and traps shall be based on the Manufacturer's recommendations for a high durability (> 15 years) coating system based on the ISO 12944-2 atmospheric corrosivity category for the asset, and the selected products shall be approved by the Company.

Notes: The actuator, meter, prover, strainer, and trap Manufacturer shall provide a letter of conformance from the paint Manufacturer. This letter shall state the surface profile range required for the paint system and shall indicate that the paint system (product names and DFT ranges) is rated for high durability for the identified ISO 12944-2 atmospheric corrosivity category for the asset.

D.1.3.2

Surface profiles, DFT, and paint systems for heat-traced and/or insulated actuators, meters, provers, strainers, and traps shall be selected from the options given for "Painting under Insulation" in PCL-ProdList for P-210. After installation and prior to heat trace and insulation, the actuators, meters, provers, strainers, and traps shall be inspected (DFTs verified) and holiday tested in the field by an Inspector (minimum NACE CIP Level 2) to ensure an intact coating.

D.1.3.3

Paint colour shall be as specified in Table A.1.

D.1.4 Surveillance

Company surveillance shall consist of a document review to ensure compliance to this appendix. The document review does not require a NACE CIP Inspector.

Appendix E
P-210 Exceptions for Structural Steel
Content Owner: Operations Engineering – Structural Engineering

E.1 Structural Steel (D04-402), Platforms, Stairs, and Ladders (D05-401), and Structural Steel (FCS-018)

E.1.1 Scope

This appendix documents an alternative paint process instead of P-210 for structural steel.

E.1.2 General Requirements

The structural steel may be painted in accordance with the structural steel Manufacturer's (i.e., fabricator's) paint procedures and shall include the requirements listed in sections E.1.3 and E.1.4.

E.1.3 Surface Preparation

E.1.3.1

Prior to painting, steel surfaces shall be examined for visible contaminants such as dirt, oil, and grease. If present, contaminants shall be removed prior to blast cleaning in accordance with SSPC SP 1 using suitable water-based cleaning agents or organic solvents. Cleaning agent residues shall be removed by rinsing the surface.

E.1.3.2

The steel shall be abrasively blasted to achieve the standard of cleanliness described in SSPC SP 6/NACE No. 3 and verified using SSPC VIS 1.

E.1.4 Paint Selection

E.1.4.1

Paint selection for uninsulated structural steel shall be based on the Manufacturer's recommendations for a high durability (> 15 years) coating system based on the ISO 12944-2 atmospheric corrosivity category for the asset, and the selected products shall be approved by the Company.

Notes: The fabricator shall provide a letter of conformance from the paint Manufacturer. This letter shall state the surface profile range required for the paint system and shall indicate that the paint system (product names and DFT ranges) is rated for high durability for the identified ISO 12944-2 atmospheric corrosivity category for the asset.

E.1.4.2

Surface profiles, DFT, and paint systems for heat-traced and/or insulated structural steel shall be selected from the options given for "Painting under Insulation" in PCL-ProdList for P-210. After installation and prior to heat trace and insulation, the actuators, meters, provers, strainers, and traps shall be inspected (DFTs verified) and holiday tested in the field by an Inspector (minimum NACE CIP Level 2) to ensure an intact coating.

E.1.4.3

Paint colour shall be as specified in Table A.1.

E.1.5 Surveillance

Company surveillance shall consist of a document review to ensure compliance to this appendix. The document review does not require a NACE CIP Inspector.

Appendix F
Exceptions for Maintenance Painting of Small Areas

F.1 Exception for Maintenance Painting of Small Areas

F.1.1 Scope
This appendix documents an alternative paint process instead of P-210 for non-immersion maintenance painting where the total repairs are less than 1 m^2 (11 ft^2).

F.1.2 Out of Scope
This appendix does not include painting under insulation and/or heat trace. Painting under insulation and/or heat trace shall follow P-210 in its entirety.

F.1.3 General Requirements

F.1.3.1
For maintenance activities, the asset may be painted in accordance with the paint Manufacturer's written instructions.

F.1.3.2
Prior to painting, a clean white rag shall be used to verify that the surface is free of contaminants such as dirt, oil, and grease. If present, contaminants shall be removed prior to blast cleaning in accordance with SSPC SP 1 using suitable water-based cleaning agents or organic solvents. Cleaning agent residues shall be removed by rinsing the surface.

F.1.3.3
The surface shall be prepared in accordance with the paint Manufacturer's written instructions.

F.1.3.4
The paint application shall be completed in accordance with the paint Manufacturer's written instructions.

F.1.4 Paint Selection

F.1.4.1
Paint selection for uninsulated valves shall be based on the paint Manufacturer's recommendations for a high durability (> 15 years) paint system based on the ISO 12944-2 atmospheric environment, and the selected products shall be approved by the Company.

F.1.4.2
Paint colour shall be as specified in Table A.1.

F.1.5 Surveillance
Company surveillance shall be as indicated in the ITP.

F.1.6 Approved Applicator
For maintenance painting of small areas, the Applicator does not need to be approved by the Company in accordance with its procurement procedures.

F.1.6.1 Painting Reporting

For maintenance painting of small areas, at minimum the following items (as applicable) shall be documented by the Applicator:

a) Inspection date
b) Applicator
c) Project
d) Inspector name and qualification
e) Identification of item inspected
f) Location of area inspected
g) Air temperature
h) Substrate temperature
i) Relative humidity
j) Surface cleanliness achieved
k) Surface profiles
l) Name, batch number, and expiry date of products used
m) Dry film thickness for each coat
n) Date and time for each coat applied

External Fusion Bond Epoxy Coating for Mainline Pipe

C-010

Protective Coating Specification

Enbridge Pipelines Inc.
Version Number: 12.0
Version Date: 2019-09-25

Document Version Control Register

1 Revision Summary

Version	Description
12.0	Complete revision Reviewed and updated to reflect current industry standards and the Company's best engineering design practices.

2 Applicability

Version	Description	Version Date
12.0	This revision is applicable to all projects that have not received an approved AFE before the effective date of this revision. Projects with an AFE approved before the effective date shall continue to abide by the previous revision. If projects with an approved AFE choose to adopt the latest revision in its entirety, a Project Decision Record is required, clearly noting the standard name, identifier, and version number. For any new revision, engineering consultants shall contact their Enbridge project team for direction on adopting the latest version. Any design changes made by engineering consultants as a result of the latest version without Enbridge project team approval will be at the engineering consultant's risk.	2019-09-25

Note: For a detailed list of changes and approval, see change log (related documents section in the GDL).

Table of Contents

1 Introduction

1.1 Scope

1.1.1
This document covers the requirements for plant application of single-layer fusion bond epoxy (FBE) coating to the external surfaces of line pipe.

1.1.2
In Canada, this specification covers the coating system defined in CSA Z245.20-18 as System 1A: single-layer FBE with a glass transition temperature of 115°C (239°F) or less.

Note: This coating system is intended primarily for the corrosion protection of line pipe in buried or submerged service. The service conditions, maximum operating temperature, and minimum installation temperatures applicable to this coating system are listed in PCL-ProdList.

1.2 Exclusions
Abrasion-resistant overcoats are not included in the scope of this specification.

Note: Refer to Company specifications C-020 and C-110 for abrasion coatings.

1.3 Purpose
The purpose of this specification is to provide consistent requirements for plant application of single-layer FBE coating to the external surfaces of line pipe.

1.4 Application

1.4.1
This specification shall be used in both Canada and the US for facilities where plant application of single-layer FBE coating to the external surfaces of line pipe is required and shall be applied by all defined parties as referenced in this specification.

1.4.2
This specification shall be used in conjunction with CSA Z245.20-18. It defines Company requirements additional to those defined in CSA Z245.20-18.

1.4.3
This document is intended to be read in conjunction with the publications listed in Section 2.

1.5 Responsibility

1.5.1
The Applicator shall be responsible for ensuring compliance with the requirements of all project-specific environmental plans and permits and applicable federal, provincial, state, and local regulations in the performance of the work.

1.5.2

The Project Engineer shall be responsible for ensuring all goods and services are supplied in accordance with the Enbridge Approved Supplier List (EASL).

1.6 Units

1.6.1

The units of measure in this document are presented first in SI units (International System of Units). US customary units (inch-pound units) follow the SI units in parentheses and might not be a direct conversion. Either system of units shall be acceptable for satisfying the requirements of the document. Users of this document should apply one system of units consistently and should not alternate between units.

1.6.2

The values presented for measurements in this document are expressed with a degree of precision appropriate for practical application and measurement. It is not intended that the application or measurement of these values be more exact than the precision expressed.

1.6.3

Any measurement value quoted directly from a publication shall be retained without conversion to preserve the integrity of the values established by the author of the source document.

1.7 Deviations

The requirements of this document shall govern. Any and all deviations from this document shall be documented and requested in accordance with the Technical Standards Deviation Request procedure or the Technical Standards Noncompliance Management procedure, as required.

2 References

2.1 Company Publications

This document refers to the following publications created by the Company; where such reference is made, it shall be to the latest edition unless otherwise specified.

Engineering Standards
Protective Coating Specification
C-020: Fusion Bond Epoxy Coating Overcoated with Powder Coating – Abrasion Coating

Protective Coating Specification
C-110: Liquid-Applied Coatings for Buried Steel

Protective Coating Specification
PCL-ProdList: Approved Product Materials

2.2 Industry Publications

This document refers to the following publications created within industry and government; where such reference is made, it shall be to the latest edition unless otherwise specified.

ASTM (ASTM International)
D7091
Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals

CSA (Canadian Standards Association)
Z245.20 Series 18
Plant-Applied External Coatings for Steel Pipe

NACE (NACE International)
SP0490
Holiday Detection of Fusion-Bonded Epoxy External Pipeline Coatings of 250 to 760 µm (10 to 30 mil)

SSPC (Society for Protective Coatings)
Guide 15
Field Methods for Extraction and Analysis of Soluble Salts on Steel and Other Nonporous Substrates

2.3 Abbreviations

The following abbreviations are applicable to this document only:

DFT	Dry film thickness
EASL	Enbridge Approved Supplier List
FBE	Fusion bond epoxy
GDL	Governance Documents Library
ITP	Inspection and test plan
MQAP	Manufacturer’s qualified application procedure
SME	Subject matter expert

2.4 Definitions

2.4.1 Technical Definitions

Definitions used in CSA Z245.20-18 shall also apply to this specification.

2.4.2 Defined Parties

The following definitions are applicable to this document only:

Applicator
The term “Applicator” shall refer to the person or company responsible for the application of paint, coating, or lining.

Company
The term “Company” shall refer to Enbridge Inc. and its representatives.

Inspector
The term “Inspector” shall refer to the Company field or shop representative responsible for performing inspections.

Manufacturer
The term “Manufacturer” shall refer to any and all involved parties that manufacture the equipment and products.

Project Engineer
The term “Project Engineer” shall refer to the person or persons responsible for designing or modifying Company facilities. The term includes all Company or contract personnel technically responsible for planned modifications to Company facilities.

2.4.3 Keywords
The following definitions are applicable to this document only:

May
Used to express an option or that which is permissible within the limits of the document

Shall
Used to express a mandatory requirement

Should
Used to express a recommendation or that which is advised but not required

3 Requirements

3.1 CSA Z245.20-18
The coating process and finished product shall comply with the requirements of CSA Z245.20-18 and the requirements in this specification for all material installed in Canada and the US.

3.2 Product Ordering

3.2.1 Standard Requirements
The following information shall be included in purchase orders and work orders for coating of pipe covered by this specification:

a) This specification (number and title)

b) Pipe quantity, pipe grade, outside diameter, wall thickness, and nominal length

c) In Canada, the coating system (System 1A)

d) Bare pipe standard or specification, including bevelling (see Section 3.16.5)

e) The cutback length approximately 15 cm [6 in.] from the bevelled edge unless specified otherwise by the Company)

f) Name and number of the applicable coating system from PCL-ProdList

Note: Refer to the latest version of PCL-ProdList for approved powders.

3.2.2 Additional Requirements

Purchase orders and work orders shall include the following additional requirements:

a) Plant inspection by the Company (see CSA Z245.20-18 Clause 7)

b) Additional markings, if applicable (see CSA Z245.20-18 Clause 9)

Note: All outside diameter stencil markings shall be black in colour.

3.3 Coating Materials

3.3.1 FBE Powder

The FBE powder used shall comply with CSA Z245.20-18. The powder Manufacturer's and Applicator's FBE test reports, required by CSA Z245.20-18, shall be submitted to the Company on request prior to the commencement of production (CSA Z245.20-18 Clause 5.2).

3.3.2 PCL-ProdList

PCL-ProdList contains the Company-approved FBE coating products. Only coating products that have been approved by the Company shall be used.

3.4 Temperature Measurements

Pipe temperature measurements shall be taken with calibrated contact pyrometers. Temperature-indicating crayons shall not be used. Infrared measurement may be used on pipe surfaces that have been coated with FBE.

3.5 Surface Profiles

3.5.1 Test Frequency

At least once every 4 h of production, the external surface profile on two pipes shall be measured using a profilometer, replicating film, or Company-approved equivalent.

3.5.2 Test Method

The external surface profile on two consecutive pipes shall be measured in three locations spaced approximately equally along each pipe length. Where the pipe being coated has a raised weld, one of the three measurements shall be on the raised weld.

3.6 Soluble Salts

3.6.1 Test Frequency

Soluble salt levels shall be tested and recorded at start-up and at least once every 2 h of blast-cleaning time thereafter (CSA Z245.20-18 Clause 6.2.2.6.2).

3.6.2 Salt Test Method

3.6.2.1
Soluble salt levels shall be tested using a method provided in SSPC Guide 15 Section 4.2.2 or 5.2.5.

3.6.2.2
The maximum soluble salt level is 4 μg/cm^2.

3.6.2.3
If the salt test level exceeds 4 μg/cm^2, the salt-contaminated pipe shall be rejected and reprocessed. The salt test frequency shall be increased by testing each individual pipe until the required salt level has been achieved.

3.6.3 Alternative Salt Test Method (Optional)

3.6.3.1
In lieu of following SSPC Guide 15, potassium ferricyanide test paper may be used for the detection of soluble salts if the Applicator has a procedure for the manufacture, application, and storage of the potassium ferricyanide test paper. The procedure shall be verified by the Inspector prior to coating and shall also meet both of the following requirements:

a) The paper shall have approximately five weight percent potassium ferricyanide.

b) The paper is stored in a sealed bag that is protected from exposure to light and marked with an expiration date of 30 days or less from the time of manufacture.

3.6.3.2
If salt is detected using the potassium ferricyanide test paper, the Applicator shall determine the soluble salt levels using SSPC Guide 15 as described in Section 3.6.2.

3.7 Acid Pre-Treatment

3.7.1 General
The Applicator shall use a phosphoric acid pre-treatment system. The pre-treatment procedure shall be submitted to and approved by the Company prior to use (CSA Z245.20-18 Clause 6.2.2.6.1). The post-rinse solution at the pipe surface shall be tested in a manner that does not contaminate the blasted steel.

3.7.2 Additional Pre-Treatments
Additional pre-treatments shall not be used unless approved by the Company (CSA Z245.20-18 Clause 6.2.2.8).

3.8 Imperfections

3.8.1 Grinding
If grinding is required after blast cleaning to remove imperfections, the remaining wall thickness shall be within Company-specified limits (refer to the corresponding Company pipe specification). The maximum grinding area per location shall not exceed 0.05 m^2 (0.5 ft^2), and the total grinding area per pipe joint shall not exceed 0.2 m^2 (2 ft^2). In any instances where the maximum grinding area or total grinding area are exceeded, the pipe shall be reblasted.

3.8.2 Repeated Blasting
Surface preparation procedures that include repeated (more than three times) or significantly slowed abrasive blast cleaning to remove imperfections shall have an average peak count between 20 – 40 peaks/cm (50 – 100 peaks/in.). The peak count shall be measured on four locations on each pipe joint. The threshold for the maximum peak to lowest valley measurement shall be 15%.

3.9 Mixing of Powder Batches
Batches of FBE powder shall not be mixed except at the point of application. Batches should be used in the order they are received.

3.10 Recycling of Powder
The first 100 µm (4 mil) of FBE applied shall be virgin. Recycled powder may be applied over the virgin powder. The percentage of recycled powder used shall not exceed the powder Manufacturer’s recommended limits. Contaminated, expired, or recovered powder (i.e., powder that has escaped from the automatic recycle system) shall not be used.

3.11 Coating Thickness

3.11.1 Thickness Measurement
Coating thickness shall be measured in at least five locations spaced approximately equally along each pipe length. Where the pipe being coated has a raised weld, one of the five required thickness measurements shall be on the raised weld. All five measured thickness values shall be recorded (CSA Z245.20-18 Clause 7.3.2.7.1).

3.11.2 Thickness Specification

3.11.2.1
The average coating thickness on any joint of pipe shall be in the range of 381 – 508 µm (15 – 20 mil).

3.11.2.2
If an individual reading is below 356 µm (14 mil), the Applicator shall perform thickness measurements every 1 m (3 ft.) along that pipe. The coating shall be rejected if one of these measurements is below 330 µm (13 mil).

3.11.2.3
If an individual coating thickness measurement is above 508 µm (20 mil), the Applicator shall perform thickness checks every 1 m (3 ft.). The pipe shall be marked in black "BEND WITH CAUTION" on both ends if the average of these readings is above 508 µm (20 mil).

3.11.3 Gauge Calibration
Coating thickness shall be measured with a calibrated thickness gauge. The thickness gauge shall be verified in the 4 h period prior to measurement using a two-point procedure as defined in ASTM D7091.

3.11.4 Excess Thickness
Only 10% of the total quantity by length in any individual pipe order may have an average coating thickness exceeding 508 µm (20 mil). Any other pipe with coating that does not meet the thickness requirements shall be stripped and recoated or, at the Company's discretion, repaired in accordance with a Company-approved procedure.

3.11.5 Overcoating
FBE coating shall be applied in a single pass through the powder application booth. Repeated passes are not allowed.

3.12 Cutback
Cutback shall be measured from the pipe root face to the edge of the epoxy powder (CSA Z245.20-18 Clause 6.2.5). The cutback length shall be approximately 15 cm (6 in.) from the bevelled edge if not directly specified by the Company (e.g., in the purchase order or ITP).

3.13 Holiday Inspection

3.13.1 NACE SP0490
Holiday inspection shall be performed in accordance with NACE SP0490 (CSA Z245.20-18 Clause 7.3.2.8.1), and the voltage shall be set at 2,100 V.

3.13.2 Holiday Detection on the Weld Seam
The entire weld seam shall be holiday tested using a handheld detector equipped with a wire brush electrode for each pipe.

3.13.3 Holiday Detection on the Main Body

3.13.3.1 Travel Speed
The holiday detector search electrode travel speed shall not exceed 1 m/s (3 ft/s). Verification of the travel speed shall be incorporated in the ITP and witnessed by the Inspector.

Note: Trials shall be done in accordance with NACE SP0490 and witnessed by the Company should the Applicator require an increased travel speed. The procedure for NACE SP0490 will be reviewed and approved prior to testing by this document's SME as indicated on the GDL. These trials shall be completed at the Applicator's expense and the results submitted to this document's SME for final approval.

3.13.3.2 Automated Units

The Applicator shall verify once per shift that the automated holiday detection system has at a minimum 25% overlap per rotation. Verification shall be incorporated into the ITP and witnessed by the Inspector.

3.13.4 Holiday Detector Verification

The holiday inspection equipment shall be calibrated at least once per working shift to confirm it is capable of detecting holidays along the full electrode coverage area (CSA Z245.20-18 Clause 7.3.2.8.1.2). This test shall be witnessed by the Inspector.

3.13.5 Size and Number of Allowable Holidays

3.13.5.1

The maximum repair area for an individual holiday before strip and recoat is listed in Table 9 of CSA Z245.20-18. The repair frequency shall be as follows:

a) Outside pipe diameter < 355.6 mm (14 in.): ≤ 0.7 holidays/m^2

b) Outside pipe diameter ≥ 355.6 mm (14 in.): ≤ 0.3 holidays/m^2

3.13.5.2

The pipe shall be stripped and recoated if the number of holidays exceeds the values listed in the previous section.

3.14 Visual Coating Anomalies

3.14.1

Each pipe shall be visually inspected for anomalies such as blisters, runs, sags, and craters (fish eyes) in the applied coating. These anomalies shall be addressed by the Applicator's quality system.

3.14.2

Imperfections in the coating caused by steel defects or debris captured under the coating that fail to be detected by holiday testing shall be repaired in accordance with CSA Z245.20-18 Clause 8.2. The defect and/or debris shall be removed and the defect area repaired.

3.15 Residual Magnetism

Residual magnetism shall be measured and recorded at start-up and every 2 h thereafter (CSA Z245.20-18 Clause 7.3.2.9).

3.16 Production Test Rings

3.16.1 General

Production test rings shall be tested according to the requirements of Table 4 in CSA Z245.20-18 with the modifications listed in sections 3.16.2 – 3.16.4.

3.16.2 24 h Cathodic Disbondment

The acceptance criterion for the 24 h cathodic disbondment at 65°C (150°F) test shall be 8 mm maximum radius.

3.16.3 Cross-Section Porosity and Interface Porosity

The acceptance criteria for cross-section porosity and interface porosity shall be 1 – 3.

3.16.4 Flexibility Test Temperature

The flexibility test temperature shall be −30°C (−22°F) unless otherwise agreed to by this document's SME as indicated on the GDL (CSA Z245.20-18 clauses 4.1.1g and 7.3.3.3).

3.16.5 Re-Bevelling

After a test ring has been taken, the pipe shall be re-bevelled as specified by the Company's pipeline specification.

3.17 Coating Adhesion

3.17.1 General

The test procedure described in CSA Z245.20-18 Clause 12.14.3 shall meet the following additional requirements:

a) The tip of the knife blade shall be inserted under the coating and shall lever the coating up at the steel/coating interface.

b) The technique used and the type and condition of the knife blade shall leave steel substrate visibly exposed at the points where the knife tip was inserted under the coating.

c) At least three corners shall be evaluated for each rectangle.

d) The adhesion rating shall be a 1 or 2 to be considered a pass.

3.18 Repair of Coated Pipe

3.18.1 Melt Sticks

Melt sticks shall not be used for coating repair.

3.18.2 Liquid-Applied Coatings for Repairs

3.18.2.1

Approved liquid-applied coatings for repairs to FBE are listed in PCL-ProdList.

3.18.2.2

The coating repairs shall be applied by an Applicator qualified in accordance with the Manufacturer's qualified application procedure (MQAP).

3.18.2.3

If the Applicator does not have a training procedure for qualifying personnel to the MQAP, the Applicator shall be qualified by the Manufacturer. Upon successful completion of the qualification training, the Manufacturer shall provide a certificate that states the following:

a) The Applicator's name
b) The coating system(s) for which the Applicator is qualified
c) The MQAP version used to qualify the Applicator
d) The date of the qualification training

3.19 Handling

3.19.1

The Applicator's handling and storage procedures shall be submitted to the Company for approval (CSA Z245.20-18 Clause 10).

3.19.2

When tape is required to secure the end ropes, Polyflex 135 or equivalent shall be used.

3.20 Additional Pipe Marking

Additional pipe marking shall be as described in the Company's purchase contract (CSA Z245.20-18 Clause 9). All outside diameter stencil markings shall be black in colour.

3.21 Atmospheric Storage of Coated Pipe

Suitable protective measures shall be in place for externally FBE-coated steel pipe stored outdoors for durations expected to exceed eight months. Refer to PCL-ProdList for Company-approved products for overcoating FBE (i.e., whitewashing).

3.22 Inspection and Test Plan

3.22.1

The Applicator shall develop and adhere to an ITP specific to the order to be coated. The ITP shall state each test or inspection that will be done and its frequency, acceptance criteria, and procedure. The ITP shall include but is not limited to the following:

a) FBE powder name
b) FBE film thickness
c) Coating repair product name and number of repairs
d) Pipe surface contamination (oil, salt, etc.)
e) Working abrasive mix, contamination, and fines

f) Blast cleanliness standard and profile
g) Blasted pipe surface particulate contamination
h) Dew point measurements of the compressed air system
i) Pipe preheat temperature
j) Quench time
k) Lab tests
l) Holiday testing
m) Type, dimensions, and location of separators on pipe

3.22.2
The section of the ITP covering the phosphoric acid pre-treatment process shall include relevant details such as the following:

a) Acid product name
b) Acid concentration
c) Pipe temperature
d) Minimum acid contact time
e) Pressure, pH, and conductivity of rinse water

3.22.3
The ITP shall be submitted to the Company for review and written approval prior to the commencement of production. The ITP and the procedures it references shall be available for review by the Company at the application facility.

4 Document Turnover
The following documents shall be submitted to the Company on the schedule agreed to between the Company and the Applicator and no later than the date of project final completion:

a) The ITP
b) A list of deviations – proposed and accepted
c) The daily calibration summary for the DFT gauge and holiday detector
d) The residual magnetism summary
e) A surface preparation summary that includes the following:
    i. Pipe surface treatment
    ii. FBE blast ambient conditions
    iii. Blotter test results
    iv. Profile measurements
    v. Salt test results
    vi. Acid wash information and results

Attachment to Enbridge Response to MPSC IR No 3

vii. Surface cleanliness

f) An FBE application summary that includes the following:
   i. Pre-application steel temperature
   ii. Post-application temperature and time between application and quenching
   iii. Powder reclaim percentage
   iv. Powder batch numbers
   v. Coating thickness measurements

g) A quality control summary that includes the following:
   i. Production ring testing summary
   ii. Holiday count summary

h) A coating marking map – proposed markings for wall thickness/coating type

i) A summary of non-conformance reports and other identified coating quality concerns/issues identified by the Manufacturer or the Company as related to the order

j) Certificate(s) of compliance for each order item

Fusion Bond Epoxy Coating Overcoated with Powder Coating - Abrasive Coating

C-020

Protective Coating Specification

Enbridge Pipelines Inc.

Version Number: 6.0

Version Date: 2019-09-25

Document Version Control Register

1 Revision Summary

Version	Description
6.0	Complete revision Reviewed and updated to reflect current industry standards and the Company's best engineering design practices.

2 Applicability

Version	Description	Version Date
6.0	This revision is applicable to all projects that have not received an approved AFE before the effective date of this revision. Projects with an AFE approved before the effective date shall continue to abide by the previous revision. If projects with an approved AFE choose to adopt the latest revision in its entirety, a Project Decision Record is required, clearly noting the standard name, identifier, and version number. For any new revision, engineering consultants shall contact their Enbridge project team for direction on adopting the latest version. Any design changes made by engineering consultants as a result of the latest version without Enbridge project team approval will be at the engineering consultant's risk.	2019-09-25

Note: For a detailed list of changes and approval, see change log (related documents section in the GDL).

Table of Contents

1 Introduction

1.1 Scope

1.1.1 Intent

1.1.1.1 Abrasion-Resistant Overcoat

This specification defines the requirements for plant application to the external surfaces of line pipe of two-layer fusion bond epoxy (FBE) coating with anti-corrosion coating and abrasion-resistant overcoat.

Note: In the pipeline coating industry, these types of coatings may be called abrasion-resistant overcoat (ARO) or dual-powder systems (DPS).

1.1.1.2 CSA Z245.20-18

This specification is intended to be used in conjunction with CSA Z245.20-18. It defines Company requirements additional to those defined in CSA Z245.20-18.

1.1.1.3 Coating Systems

This specification covers CSA Z245.20-18 System 2B: two-layer FBE with an anti-corrosion coating and an ARO.

Note: The coated pipe is intended primarily for buried service where a high degree of abrasion is anticipated, such as slip bore and directional drill installations. The maximum operating temperature and applicable coating systems are listed in PCL-ProdList.

1.2 Exclusions

Liquid-applied abrasion-resistant coatings are not included in the scope of this specification.

Note: Refer to C-110 for liquid-applied abrasion coatings.

1.3 Purpose

The purpose of this specification is to provide consistent requirements for plant application to the external surfaces of line pipe of two-layer FBE coating with anti-corrosion coating and ARO.

1.4 Application

1.4.1

This specification shall be used in both Canada and the US for any new and existing facilities where plant application to the external surfaces of line pipe of two-layer FBE coating with anti-corrosion coating and ARO is required and shall be applied by all defined parties as referenced in this specification.

1.4.2

This document is intended to be read in conjunction with the publications listed in Section 2.

1.5 Responsibility

1.5.1

The Applicator shall be responsible for ensuring compliance to the requirements of all project-specific environmental plans and permits and applicable federal, provincial, state, and local regulations in the performance of the work.

1.5.2

The Project Engineer shall be responsible for ensuring all goods and services are supplied in accordance with the Enbridge Approved Supplier List (EASL).

1.6 Units

1.6.1

The units of measure in this document are presented first in SI units (International System of Units). US customary units (inch-pound units) follow the SI units in parentheses and might not be a direct conversion. Either system of units shall be acceptable for satisfying the requirements of the document. Users of this document should apply one system of units consistently and should not alternate between units.

1.6.2

The values presented for measurements in this document are expressed with a degree of precision appropriate for practical application and measurement. It is not intended that the application or measurement of these values be more exact than the precision expressed.

1.6.3

Any measurement value quoted directly from a publication shall be retained without conversion to preserve the integrity of the values established by the author of the source document.

1.7 Deviations

The requirements of this document shall govern. Any and all deviations from this document shall be documented and requested in accordance with the Technical Standards Deviation Request procedure or the Technical Standards Noncompliance Management procedure, as required.

2 References

2.1 Company Publications

This document refers to the following publications created by the Company; where such reference is made, it shall be to the latest edition unless otherwise specified.

Engineering Standards
Protective Coating Specification
C-110: Liquid-Applied Coatings for Buried Steel

Protective Coating Specification
PCL-ProdList: Approved Product Materials

2.2 Industry Publications

This document refers to the following publications created within industry and government; where such reference is made, it shall be to the latest edition unless otherwise specified.

ASTM (ASTM International)
D7091
Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals

CSA (Canadian Standards Association)
CSA Z245.20 Series 18
Plant-Applied External Coatings for Steel Pipe

NACE (NACE International)
SP0490
Holiday Detection of Fusion-Bonded Epoxy External Pipeline Coatings of 250 to 760 µm (10 to 30 mil)

SSPC (Society for Protective Coatings)
Guide 15
Field Methods for Extraction and Analysis of Soluble Salts on Steel and Other Nonporous Substrates

2.3 Abbreviations

The following abbreviations are applicable to this document only:

ARO	Abrasion-resistant overcoat
DPS	Dual-powder systems
EASL	Enbridge Approved Supplier List
FBE	Fusion bond epoxy
GDL	Governance Documents Library
MQAP	Manufacturer’s qualified application procedure
SME	Subject matter expert

2.4 Definitions

2.4.1 Technical Definitions

Definitions used in CSA Z245.20-18 shall also apply to this specification.

2.4.2 Defined Parties

The following definitions are applicable to this document only:

Applicator
The term “Applicator” shall refer to the person or company responsible for the application of paint, coating, or lining.

Company
The term “Company” shall refer to Enbridge Inc. and its representatives.

Inspector
The term “Inspector” shall refer to the Company field or shop representative responsible for performing inspections.

Manufacturer
The term “Manufacturer” shall refer to any and all involved parties that manufacture the equipment and products.

Project Engineer
The term “Project Engineer” shall refer to the person or persons responsible for designing or modifying Company facilities. The term includes all Company or contract personnel technically responsible for planned modifications to Company facilities.

2.4.3 Keywords

The following definitions are applicable to this document only:

May
Used to express an option or that which is permissible within the limits of the document

Shall
Used to express a mandatory requirement

Should
Used to express a recommendation or that which is advised but not required

3 Requirements

3.1 CSA Z245.20-18

The coating process and finished product shall comply with the requirements of CSA Z245.20-18 and the requirements in this specification for all material installed in Canada and the US.

3.2 Product Ordering

3.2.1 Standard Requirements

The following information shall be included in purchase orders for coating for pipe covered by this specification (CSA Z245.20-18 Clause 4.1):

a) This specification (document number, title, and version)

b) Pipe quantity, outside diameter, wall thickness, and nominal length

c) Coating system 2B

d) Bare pipe standard or specification, including bevelling (see Section 3.17.9)

e) The cutback length (approximately 15 cm (6 in.) from the bevelled edge if not directly specified by the Company)

f) Name and number of the applicable coating system in PCL-ProdList

Note: PCL-ProdList contains the coating system specifications, approved powders, and approved repair materials.

g) Cutback length and tolerance for both ends of pipe (CSA Z245.20-18 Clause 6.2.5)

h) Test temperature for the flexibility test (−30°C [−22°F]; see Section 3.17.4)

3.2.2 Additional Requirements

Purchase orders shall include the following additional requirements:

a) Plant inspection by the Company (see CSA Z245.20-18 Clause 7)

b) Additional markings, if applicable (see CSA Z245.20-18 Clause 9)

Note: All outside diameter stencil markings shall be black in colour.

3.3 Coating Materials

3.3.1 Powders

The powders used shall comply with CSA Z245.20-18. The powder Manufacturer's and Applicator's FBE test reports, required by CSA Z245.20-18, shall be submitted to the Company upon request prior to the commencement of production (CSA Z245.20-18 Clause 5.2).

3.3.2 PCL-ProdList

PCL-ProdList contains the Company-approved FBE/ARO coating products. Only coating products that have been approved by the Company shall be used.

3.4 Temperature Measurement

Pipe temperature measurements shall be taken with contact pyrometers that meet the Company's approval. Temperature-indicating crayons shall not be used. Infrared methods may be used immediately after the powder booth when the coating has been applied.

3.5 Surface Profiles

3.5.1 Test Frequency
At least once every 4 h of production, the external surface profile on two pipes shall be measured using a profilometer, replicating film, or Company-approved equivalent.

3.5.2 Test Method
The external surface profile on two consecutive pipes shall be measured in three locations spaced equally along each pipe length. Where the pipe being coated has a raised weld, one of the three measurements shall be on the raised weld.

3.6 Soluble Salts

3.6.1 Test Frequency
Soluble salt levels shall be tested and recorded at start-up and at least once every 2 h of blast-cleaning time thereafter (CSA Z245.20-18 Clause 6.2.2.6.2).

3.6.2 Salt Test Method

3.6.2.1
Soluble salt levels shall be tested using a method provided in SSPC Guide 15 Section 4.2.2 or 5.2.5.

3.6.2.2
The maximum soluble salt level is 4 $\mu g/cm^2$.

3.6.2.3
If the salt test level exceeds 4 $\mu g/cm^2$, the salt-contaminated pipe shall be rejected and reprocessed. The salt test frequency shall be increased by testing each individual pipe until the required salt level has been achieved.

3.6.3 Alternative Salt Test Method (Optional)

3.6.3.1
In lieu of following SSPC Guide 15, potassium ferricyanide test paper may be used for the detection of soluble salts if the Applicator has a procedure for the manufacture, application, and storage of the potassium ferricyanide test paper. The procedure shall be verified by the Inspector prior to coating and shall also meet both of the following requirements:

a) The paper shall have approximately five weight percent potassium ferricyanide.
b) The paper is stored in a sealed bag that is protected from exposure to light and marked with an expiration date of 30 days or less from the time of manufacture.

3.6.3.2
If salt is detected using the potassium ferricyanide test paper, the Applicator shall determine the soluble salt levels using SSPC Guide 15 as described in Section 3.6.2.

3.7 Acid Pre-Treatment

3.7.1 General
The Applicator shall use a phosphoric acid pre-treatment system. The pre-treatment procedure shall be submitted to and approved by the Company prior to use (CSA Z245.20-18 Clause 6.2.2.6.1). The post-rinse solution at the pipe surface shall be tested in a manner that does not contaminate the blasted steel.

3.7.2 Additional Pre-Treatments
Additional pre-treatments shall not be used unless approved by the Company (CSA Z245.20-18 Clause 6.2.2.8).

3.8 Imperfections

3.8.1 Grinding
If grinding is required after blast cleaning to remove imperfections, the remaining wall thickness shall be within Company-specified limits (refer to the corresponding Company pipe specification). The maximum grinding area per location shall not exceed 0.05 m^2 (0.5 ft^2), and the total grinding area per pipe joint shall not exceed 0.2 m^2 (2 ft^2). In any instances where the maximum grinding area or total grinding area are exceeded, the pipe shall be reblasted.

3.8.2 Repeated Blasting
Surface preparation procedures that include repeated (more than three times) or significantly slowed abrasive blast cleaning to remove imperfections shall have an average peak count between 20 – 40 peaks/cm (50 – 100 peaks/in.). The peak count shall be measured on four locations on each reblasted pipe joint. The threshold for the maximum peak to lowest valley measurement shall be 15%.

3.9 Mixing of Powder Batches
Batches of FBE powder shall not be mixed except at the point of application. Batches should be used in the order that they are received. Overcoating powder shall not be mixed with or used in the anti-corrosion coating.

3.10 Recycling of Powder
The first 100 µm (4 mil) of FBE applied shall be virgin. Recycled powder may be applied over the virgin powder. The percentage of recycled powder used shall not exceed the powder Manufacturer’s recommended limits. Contaminated, expired, or recovered powder (i.e., powder that has escaped from the automatic recycle system) shall not be used.

3.11 Application and Curing

3.11.1 General
The interval between application of the anti-corrosion coating and application of the overcoat shall be within the limits specified by the Manufacturer. The applied coating shall be cured in accordance with the powder Manufacturer’s recommendations (CSA Z245.20-18 Clause 6.2.3).

3.11.2 Overcoating
The full coating system shall be applied in a single pass through the powder application booth; repeated passes are not allowed.

3.12 Thickness Requirements

3.12.1 Anti-Corrosion Coating Thickness (FBE Only)

3.12.1.1
The average anti-corrosion coating thickness on any joint of pipe shall be in the range of 381 – 508 µm (15 – 20 mil).

3.12.1.2
If an individual reading is below 356 µm (14 mil), the Applicator shall perform thickness measurements every 1 m (3 ft.) along that pipe. The coating shall be rejected if one of these measurements is below 330 µm (13 mil). The anti-corrosion coating thickness of pipe before and after the rejected pipe shall be measured until found to be compliant.

3.12.1.3 Total Coating Thickness (FBE and ARO)

3.12.1.3.1
The average total coating thickness on any joint of pipe shall be in the range of 1,020 – 1,372 µm (40 – 54 mil).

3.12.1.3.2
The total coating thickness (FBE and ARO) shall be measured in at least five locations spaced equally along each pipe length. Where the pipe being coated has a raised weld, one of the five required thickness measurements shall be on the raised weld. All five measured thickness values shall be recorded (CSA Z245.20-18 Clause 7.3.2.7.1).

3.12.2 Thickness Measurement of Individual Layers
The thickness of each individual layer shall be measured and recorded as required by CSA Z245.20-18 at least once per hour (CSA Z245.20-18 Clause 7.3.2.7.1.2).

3.12.3 Gauge Calibration
Coating thickness shall be measured with a calibrated thickness gauge. The thickness gauge shall be verified in the 4 h period prior to measurement using a two-point procedure as defined in ASTM D7091.

3.13 Cutback
Cutback shall be measured from the pipe root face to the edge of the epoxy powder (CSA Z245.20-18 Clause 6.2.5). The cutback length shall be approximately 15 cm (6 in.) from the bevelled edge if not directly specified by the Company (e.g., in the purchase order or ITP).

3.14 Holiday Inspection

3.14.1 Holiday Voltage

Holiday inspection shall be performed in accordance with CSA Z245.20-18 Clause 7.3.2.8, and the voltage shall be set at 5,000 V.

3.14.2 Holiday Detection on the Weld Seam

The entire weld seam shall be holiday tested using a handheld detector equipped with a wire brush electrode for each pipe.

3.14.3 Holiday Detection on the Main Body

3.14.3.1 Travel Speed

The holiday detector search electrode travel speed shall not exceed 1 m/s (3 ft/s). Verification of the travel speed shall be incorporated in the ITP and witnessed by the Inspector.

Note: Trials shall be done in accordance with NACE SP0490 and witnessed by the Company should the Applicator require an increased travel speed. The procedure for NACE SP0490 will be reviewed and approved prior to testing by this document's SME as indicated on the GDL. These trials shall be completed at the Applicator's expense and the results submitted to this document's SME for final approval.

3.14.3.2 Automated Units

The Applicator shall verify once per shift that the automated holiday detection system has at a minimum 25% overlap per rotation. Verification shall be incorporated into the ITP and witnessed by the Inspector.

3.14.4 Holiday Detector Verification

The holiday inspection equipment shall be calibrated at least once per working shift to confirm it is capable of detecting holidays along the full electrode coverage area (CSA Z245.20-18 Clause 7.3.2.8.1.2). This test shall be witnessed by the Inspector.

3.14.5 Size and Number of Allowable Holidays

3.14.5.1

The maximum repair area for an individual holiday before strip and recoat is listed in Table 9 of CSA Z245.20-18. The repair frequency shall be as follows:

a) Outside pipe diameter < 355.6 mm (14 in.): ≤ 0.7 holidays/m^2

b) Outside pipe diameter ≥ 355.6 mm (14 in.): ≤ 0.3 holidays/m^2

3.14.5.2

The pipe shall be stripped and recoated if the number of holidays exceeds the values listed in the previous section.

3.15 Visual Coating Anomalies

3.15.1

Each pipe shall be visually inspected for anomalies such as blisters, runs, sags, and craters (fish eyes) in the applied coating. These anomalies shall be addressed by the Applicator's quality system.

3.15.2

Imperfections in the coating caused by steel defects or debris captured under the coating that fail to be detected by the holiday testing shall be repaired in accordance with CSA Z245.20 Clause 8.2. The defect and/or debris shall be removed, and coating repair shall be applied to the defect area.

3.16 Residual Magnetism

Residual magnetism shall be measured and recorded at start-up and every 2 h thereafter (CSA Z245.20-18 Clause 7.3.2.9.3).

3.17 Production Test Rings

3.17.1 General

Production test rings shall be tested according to the requirements of Table 8 in CSA Z245.20-18 with the modifications listed in sections 3.17.2 – 3.17.7. The minimum test frequency for the FBE/ARO shall be one test ring per pipe diameter and specified wall thickness every working shift.

3.17.2 24 h Cathodic Disbondment

The acceptance criterion for the 24 h cathodic disbondment at 65°C (150°F) test shall be 8 mm maximum radius.

3.17.3 Cross-Section Porosity and Interface Porosity

The acceptance criteria for cross-section porosity and interface porosity shall be 1 – 3.

3.17.4 Flexibility Test Temperature

The acceptance criterion for flexibility testing is no cracks after bending the sample to 1.5° at −30°C (−22°F). The flexibility resistance test temperature shall be −30°C (−22°F) unless otherwise agreed to by this document's SME as indicated on the GDL (CSA Z245.20-18 clauses 4.1.1g and 7.3.3.3).

3.17.5 Impact Resistance

The acceptance criterion for impact resistance is no holidays after testing at 3 J with a test temperature of −30°C (−22°F) per CSA Z245.20-18 Clause 12.12. Testing for the presence of holidays shall be completed using a voltage between 1,500 – 2,000 V.

3.17.6 Coating Adhesion

The test procedure described in CSA Z245.20-18 Clause 12.14.3 shall meet the following additional requirements:

a) The tip of the knife blade shall be inserted under the coating and shall lever the coating up at the steel/coating interface.

b) The technique used and the type and condition of the knife blade shall leave steel substrate visibly exposed at the points where the knife tip was inserted under the coating.

c) At least three corners shall be evaluated for each rectangle.

d) The adhesion rating shall be a 1 or 2 to be considered a pass.

3.17.7 Gouge Test

3.17.7.1

Gouge resistance using a SL-1 single cut gouging bit per CSA Z245.20-18 Clause 12.15 shall also be performed.

3.17.7.2

The acceptance criterion shall be average (mean) gouge depth less than 500 µm (20 mil). The test type shall be Type B.

3.17.7.3

The frequency of testing shall be once per production week.

3.17.7.4

Gouge depth measurements shall be recorded and included in the CSA Z245.20-18 Table 8 production testing reports.

3.17.8 Anti-Corrosion Coat Only

3.17.8.1 General

Once per production week, a production ring that only has the applied anti-corrosion coating shall be taken. The production test rings shall be tested according to the requirements of Table 4 in CSA Z245.20-18 with the modifications listed in sections 3.17.8.2 to 3.17.8.4.

3.17.8.2 24 h Cathodic Disbondment

The acceptance criterion for the 24 h cathodic disbondment at 65°C (150°F) test shall be 8 mm maximum radius.

3.17.8.3 Cross-Section Porosity and Interface Porosity

The acceptance criteria for cross-section porosity and interface porosity shall be 1 – 3.

3.17.8.4 Flexibility Test Temperature

The flexibility test temperature shall be −30°C (−22°F) unless otherwise agreed to by this document's SME as indicated on the GDL (CSA Z245.20-18 clauses 4.1.1g and 7.3.3.3).

3.17.8.5 Coating Adhesion

The test procedure described in CSA Z245.20-18 Clause 12.14.3 shall meet the following additional requirements:

a) The tip of the knife blade shall be inserted under the coating and shall lever the coating up at the steel/coating interface.

b) The technique used and the type and condition of the knife blade shall leave steel substrate visibly exposed at the points where the knife tip was inserted under the coating.

c) At least three corners shall be evaluated for each rectangle.

d) The adhesion rating shall be a 1 or 2 to be considered a pass.

3.17.9 Re-Bevelling

After a test ring has been taken, the pipe shall be re-bevelled as specified by the Company's pipeline specification.

3.18 Repair of Coated Pipe

3.18.1 Melt Sticks

Melt sticks shall not be used for coating repair.

3.18.2 Liquid-Applied Coatings for Repairs

3.18.2.1

Approved liquid-applied coatings for repairs to FBE are listed in PCL-ProdList.

3.18.2.2

The coating repairs shall be applied by an Applicator qualified in accordance with the Manufacturer's qualified application procedure (MQAP).

3.18.2.3

If the Applicator does not have a training procedure for qualifying personnel to the MQAP, the Applicator shall be qualified by the Manufacturer. Upon successful completion of the qualification training, the Manufacturer shall provide a certificate that states the following:

a) The Applicator's name

b) The coating system(s) for which the Applicator is qualified

c) The MQAP version used to qualify the Applicator

d) The date of the qualification training

3.18.2.4

Applicators shall complete retraining every two years from the date of the previous qualification.

3.19 Handling

3.19.1

The Applicator’s handling and storage procedures shall be submitted to the Company for approval (CSA Z245.20-18 Clause 10).

3.19.2

When tape is required to secure the end ropes, Polyflex 135 or equivalent shall be used.

3.20 Additional Pipe Marking

Additional pipe marking shall be as described in the Company’s purchase contract (CSA Z245.20-18 Clause 9). All outside diameter stencil markings shall be black in colour.

3.21 Atmospheric Storage of Coated Pipe

Suitable protective measures shall be in place for externally FBE-coated steel pipe stored outdoors for durations expected to exceed eight months. Refer to PCL-ProdList for Company-approved products for overcoating FBE (i.e., whitewashing).

3.22 Inspection and Test Plan

3.22.1

The Applicator shall develop and adhere to an inspection and test plan (ITP) specific to the order to be coated. The ITP shall state each test or inspection that will be done and its frequency, acceptance criteria, and procedure. The ITP shall include but not be limited to the following:

a) Project name
b) Powder names
c) Film thicknesses
d) Coating repair product name and number of repairs
e) Pipe surface contamination (oil, salt, etc.)
f) Working abrasive mix, contamination, and fines
g) Blast cleanliness standard and profile
h) Blasted pipe surface particulate contamination
i) Salt test
j) Compressed air system dew point and cleanliness tests
k) Pipe preheat temperature
l) Quench time
m) Laboratory quality control tests on raw materials and applied coating
n) Holiday testing
o) Type, dimensions, and location of separators on pipe

3.22.2

The section of the ITP covering the phosphoric acid pre-treatment process shall include relevant details such as the following:

a) Acid product name
b) Acid concentration
c) Pipe temperature
d) Minimum acid contact time
e) Pressure, pH, and conductivity of rinse water

3.22.3

The ITP shall be submitted to the Company for review and written approval prior to the commencement of production. The ITP and the procedures it references shall be available for review by the Company at the application facility.

4 Document Turnover

The following documents shall be submitted to the Company on the schedule agreed to between the Company and the Applicator and no later than the date of project final completion:

a) The ITP
b) A list of deviations – proposed and accepted
c) The daily calibration summary for the DFT gauge and holiday detector
d) The residual magnetism summary
e) A surface preparation summary that includes the following:
    i. Pipe surface treatment
    ii. FBE blast ambient conditions
    iii. Blotter test results
    iv. Profile measurements
    v. Salt test results
    vi. Acid wash information and results
    vii. Surface cleanliness
f) An FBE application summary that includes the following:
    i. Pre-application steel temperature
    ii. Post-application temperature and time between application and quenching
    iii. Powder reclaim percentage
    iv. Powder batch numbers
    v. Coating thickness measurements

g) A quality control summary that includes the following:
   i. Production ring testing summary
   ii. Holiday count summary
h) A coating marking map – proposed markings for wall thickness/coating type
i) A summary of non-conformance reports and other identified coating quality concerns/issues identified by the Manufacturer or the Company as related to the order
j) Certificate(s) of compliance for each order item

FIRST DISCOVERY REQUESTS TO ENBRIDGE ENERGY, LIMITED PARTNERSHIP BY THE MICHIGAN PUBLIC SERVICE COMMISSION STAFF

Utility Information Request

☑ Public Document

Docket Numbers: Case No. U-20763 Date of Request: September 10, 2020

Requested From: Enbridge Energy, Limited Partnership Response Due: September 24, 2020

Objection By: Michael Ashton, Counsel

Response By: Aaron Dennis, Engineer Specialist

If you feel your responses are trade secret or privileged, please indicate this on your response.

Request No.	
4	Subject: Pipe Support Spacing within the Tunnel

Request: Please provide the specifications that will be used to govern pipeline support spacing within the tunnel.

Objection: To the extent that this request seeks information concerning the safety and integrity of the replacement pipeline, these issues are ultimately subject to the exclusive regulatory authority of the Pipeline and Hazardous Materials Safety Administration, and Enbridge therefore objects as the information sought is irrelevant.

Response: Without waiving the above objection, the support span spacing for the pipeline will be designed in accordance with Enbridge Design Standards D06-102 Section 4.8.2.2 (see attached) and ASME B31.4 2006 Section 421.

4.8.1.6

Where they are required, welded wear plates used for support shall comply with the following:

a) For Canadian applications designed to CSA Z662, welded wear plates shall be full-encirclement saddle type unless pipe design hoop stress is less than 50% of SMYS.

b) For US applications designed to ASME B31.4 and CFR Title 49 Part 195, both of the following conditions shall be met:

   i. Welded wear plates shall be full-encirclement saddle type unless pipe design hoop stress is less than 20% of SMYS.

   ii. Welded wear plates can be installed if the maximum operating pressure is less than 700 kPag (100 psig).

4.8.2 Aboveground Piping

4.8.2.1

The maximum allowable pipe support spacings shall be as indicated in Table 4.10

Table 4.10 – Above-Grade Pipe Support Spacing

Nominal Pipe Size		Pipe Support Spacing (max.)	
60.3 mm	2 in.	6.1 m	20.0 ft.
88.9 mm	3 in.	7.6 m	24.9 ft.
114.3 mm	4 in.	8.4 m	27.5 ft.
168.3 mm	6 in.	9.6 m	31.5 ft.
219.1 mm	8 in.	10.9 m	35.8 ft.
273.0 mm	10 in.	12.1 m	39.7 ft.
323.9 mm	12 in.	12.2 m	40.0 ft.
355.6 mm	14 in.	13.0 m	42.6 ft.
406.4 mm	16 in.	13.0 m	42.6 ft.
457.0 mm	18 in.	13.7 m	44.9 ft.
508.0 mm	20 in.	14.0 m	45.9 ft.
610.0 mm	24 in.	14.2 m	46.6 ft.

4.8.2.2

The following requirements pertain to above-grade piping, including rack piping:

a) The minimum pipe size to be carried on pipe racks should be 60.3 mm (NPS 2).

b) For lines 660.4 mm (NPS 26) and larger, a formal piping stress analysis shall be completed to determine pipe support spacing. In addition, flange leakage checks shall be performed at locations experiencing high piping stresses.

c) Relief piping shall be firmly supported to counteract the reaction force of the discharging fluid.

d) The maximum pipe support spans indicated in Table 4.10 are based on water-filled bare pipe.

e) Point loads such as valves shall be given special consideration. These loads may need to be supported with separate supports or by reducing pipe support spacing.

f) Pipe support spacing shall be determined such that the maximum piping deflection between supports due to sustained loads does not exceed 12.7 mm (0.5 in.).

g) Requirements for guides and anchors on above-grade rack piping shall be based on piping stress analysis.

h) Station piping in the vicinity of mainline pumps shall be supported at spans not greater than 6.1 m (20 ft.) on centre. At support locations, provided that pipe flexibility remains acceptable, station piping should be fitted with clamps.

4.8.2.3

Structural support shall take into consideration deflection/stiffness and dampening in all directions, as station piping in the vicinity of mainline pumps is considered to be in high vibration service.

4.8.2.4

Unsupported vertical loops shall be avoided in the station piping layouts.

4.8.2.5

Electrical isolation of the pipe from the supports shall be incorporated wherever possible to prevent cathodic corrosion.

4.8.3 Buried Piping

4.8.3.1

Generally, buried piping in stations and terminals should be continuously supported on undisturbed soil. Backfill under buried piping due to over-excavation or removal of soft spots shall be compacted to 95% Standard Proctor prior to placement of pipe. Refer to D05-103 for additional requirements for buried piping, including for cover and clearance .

4.8.3.2

The piping design shall consider loads imposed on piping, equipment, and tank nozzles as a result of thermal pressure and differential settlement effects as well as frost heave and frost jacking.

4.9 Branch Connections

4.9.1

The design of branch connections on piping systems shall be a quality stream configuration that minimizes the volume of dead pockets, dead ends, or bypass lines that could introduce a foreign commodity into the flowing stream. Block valves, check valves, and pipe fittings shall be configured to minimize product contamination. Pipe fittings should be fitting-to-fitting when possible.

FIRST DISCOVERY REQUESTS TO ENBRIDGE ENERGY, LIMITED PARTNERSHIP BY THE MICHIGAN PUBLIC SERVICE COMMISSION STAFF

Utility Information Request

☑ Public Document

Docket Numbers: Case No. U-20763 Date of Request: September 10, 2020

Requested From: Enbridge Energy, Limited Partnership Response Due: September 24, 2020

Objection By: Michael Ashton, Counsel

Response By: Aaron Dennis, Engineer Specialist

If you feel your responses are trade secret or privileged, please indicate this on your response.

Request No.	
5	Subject: Description of the Pipeline Supports within the Tunnel
Request:	Please provide a detailed description of the pipeline support mechanism within the tunnel.
Objection:	To the extent that this request seeks information concerning the safety and integrity of the replacement pipeline, these issues are ultimately subject to the exclusive regulatory authority of the Pipeline and Hazardous Materials Safety Administration, and Enbridge therefore objects as the information sought is irrelevant.
Response:	Without waiving the above objection, there are three general types of supports (Types A-C) that will be designed to AISC 360 and placed at approximately every 48 feet on center along the pipeline within the tunnel. All pipeline supports have been designed to accommodate loading from the initial pipeline installation, hydrotest loading conditions, and operating conditions of the pipeline, including but not limited to expansion/contraction of the pipeline due to ambient and product temperature variations. The Type A support is a vertical support with dual concave roller bearings at each support as illustrated in Figure 1. The roller bearings are attached to a structural steel frame assembly anchored to the bottom and sides of the tunnel. A horizontal brace is also provided to transfer longitudinal loads during installation to the tunnel wall section.

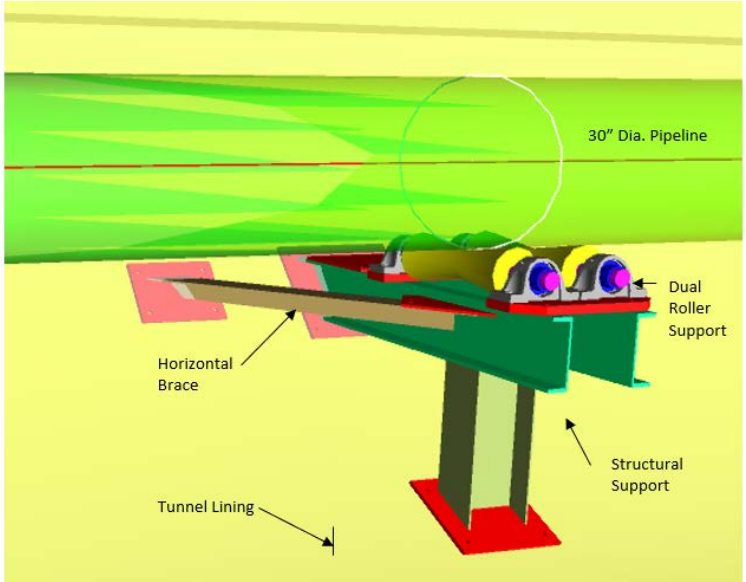

Figure 1 – Isometric of Type A Tunnel Support

Type B supports are guide supports which provide the dual roller vertical support like the Type A supports but also include side rollers to maintain the pipeline in its design horizontal position. These supports are located adjacent to and throughout the horizontal and vertical bends of the pipeline and are also located at every fourth support (approximately 196 feet) along straight sections of the pipeline to prevent buckling. A Type B support is shown in Figure 2.

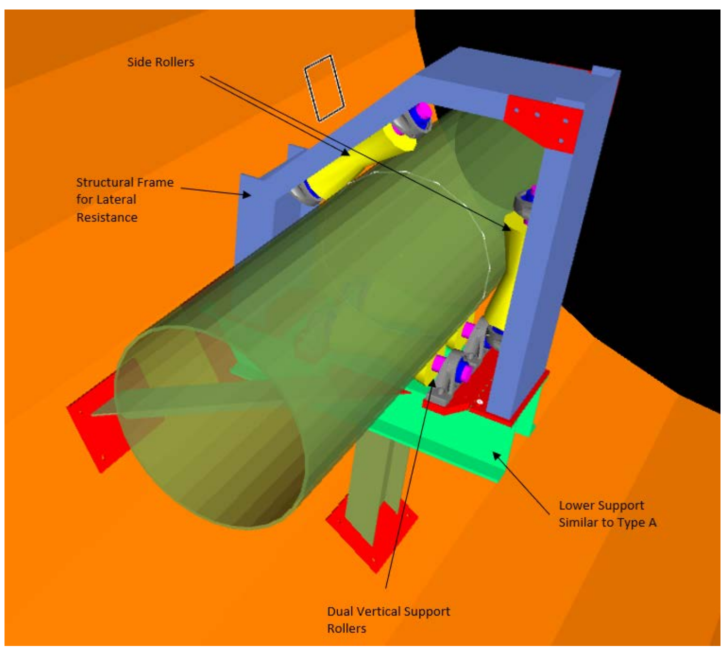

Figure 2 – Isometric of Type B Guide Support

At each end of the tunnel, the structural support (Type C) will utilize a PTFE (teflon) slide bearing assembly to accommodate longitudinal movement of the pipeline. A welded pipe saddle will be welded to the pipeline and will be supported by the slide bearing. The slide bearing assembly is attached to a lower structural support of similar configuration to the Type A support. See Figure 3.

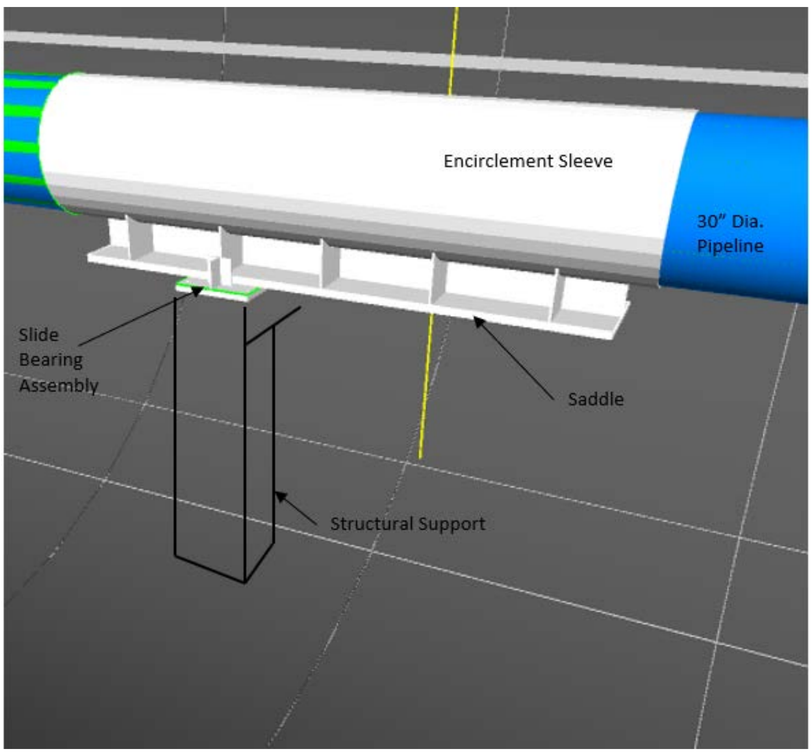

Figure 3 – Isometric of Tunnel End Supports

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Requested From: Enbridge Energy, Limited Partnership Response Due: September 24, 2020

Objection By: Michael Ashton, Counsel

Response By: Aaron Dennis, Engineer Specialist

If you feel your responses are trade secret or privileged, please indicate this on your response.

Request No.	
10	Subject: Pipeline Bends
Request:	Please indicate if any pipe bends will be used in construction of the pipeline. If so, please provide the specification used to govern the pipe bend construction.
Objection:	To the extent that this request seeks information concerning the safety and integrity of the replacement pipeline, these issues are ultimately subject to the exclusive regulatory authority of the Pipeline and Hazardous Materials Safety Administration, and Enbridge therefore objects as the information sought is irrelevant.
Response:	Without waiving the objection, pipeline bends will be used in the construction of the pipeline. All bends will be constructed in accordance with the following Enbridge standards that implement and comply with applicable federal requirements specified in 49 C.F.R. Part 195 and industry standards, including ASME B16.49, SME B31.4, and API Specification 5L: Steel Pipe Induction Bends (Supplementary to ASME B16.49-2012) – attached Submerged-Arc-Welded Steel Pipe Supplementary to API 5L - attached

Steel Pipe Induction Bends (Supplementary to ASME B16.49-2012)

EES071

Engineering Equipment Specification

Enbridge Pipelines Inc.
Version Number: 3.0
Version Date: 2017-07-26

Document Version Control Register

1 Revision Summary

Version	Description
3.0	Complete revision Reviewed and updated to reflect current industry standards and the Company's best engineering design practices

2 Applicability

Version	Description	Version Date
3.0	This revision is applicable to all projects that have not received an approved AFE before the effective date of this revision. Projects with an AFE approved before the effective date shall continue to abide by the previous revision. If projects with an approved AFE choose to adopt the latest revision in its entirety, a Project Decision Record is required, clearly noting the standard name, identifier, and version number. For any new revision, engineering consultants shall contact their Enbridge project team for direction on adopting the latest version. Any design changes made by engineering consultants as a result of the latest version without Enbridge project team approval will be at the engineering consultant's risk.	2017-07-26

Note: for a detailed list of changes and approval, see change log (related documents section in the GDL).

Table of Contents

1 Scope and Definitions

1.1 General

1.1.1 Supplementary Specification (Addition)

1.1.1.1 Use

This supplementary specification (SS) shall be applied in conjunction with ASME B16.49-2012, hereafter referred to as the parent document (PD), for factory-made, wrought steel, buttwelding induction bends for transportation and distribution systems.

1.1.1.2 Identifiers

Each section of this specification is labelled with an identifier that informs the user how the content in the section is to be applied relative to the PD. The identifiers are given as follows:

Addition
This section is new, in its entirety, to the PD.

Decision
This section contains a decision made by the Company on a choice presented in the corresponding section of the PD.

Exception
This section of the PD shall not be implemented by the Company. If the corresponding section of the PD is not exempted in its entirety, the applicable content will be highlighted as an omission.

Modification
The content in this section is additional to the content in the corresponding section of the PD.

Substitution
The content in this section replaces the content in the corresponding section of the PD. If the corresponding section in the PD is not substituted in its entirety, the applicable content will be highlighted as an omission and the substitution will be inserted.

Notes:

1. Any content highlighted as an omission will not be a requirement. Omissions are used with exceptions and substitutions only when the corresponding section of the PD is not exempted or substituted in its entirety.
2. Any content highlighted as an insertion will be a requirement. Insertions are used with substitutions only when the corresponding section of the PD is not substituted in its entirety.

1.1.2 Application (Addition)

The requirements of this specification are applicable in Canada and the US and comply with Canadian and US regulations. In the event that a conflict exists between this specification and the requirements of the PD, the more stringent requirement(s) shall govern.

1.1.3 Deviations (Addition)

Any and all deviations from this standard shall be documented and requested in accordance with the Technical Standards Deviation Request procedure or the Technical Standards Noncompliance Management procedure, as required.

1.1.4 (Addition)

Pipe bends manufactured to this specification are intended for installation in non-sour liquid pipelines and related facilities and are constructed in accordance with the National Energy Board – Onshore Pipeline Regulations (SOR/99-294) in Canada and the Code of Federal Regulations (CFR) Title 49, Part 195 in the US. Bends shall meet the applicable requirements of this specification and any additional references in the purchasing documents.

1.1.5 (Addition)

This specification is not intended to cover requirements for sour services.

1.5 References

1.5.1 Company Publications (Addition)

This document refers to the following publications created by the Company; where such reference is made, it shall be to the latest edition unless otherwise specified.

Engineering Standards
Engineering Equipment Specification
EES100: Electric-welded Steel Pipe (Supplementary to CSA Z245.1)

Engineering Equipment Specification
EES101: Electric-Welded Steel Pipe (Supplementary to API 5L)

Engineering Equipment Specification
EES102: Submerged-Arc-Welded Steel Pipe (Supplementary to CSA Z245.1-07)

Engineering Equipment Specification
EES103: Submerged-Arc Welded Steel Pipe (Supplementary to API 5L)

1.5.2 Industry Publications (Addition)

This document refers to the following publications created within industry; where such reference is made, it shall be to the latest edition unless otherwise specified.

ASME (ASME International)
B16.49
Factory-Made, Wrought Steel, Buttwelding Induction Bends for Transportation and Distribution Systems

B31.4
Pipeline Transportation Systems for Liquids and Slurries

ASME/BPVC (ASME International)
SEC VIII-1
Rules for Construction of Pressure Vessels – Division 1

ASNT (American Society for Nondestructive Testing)
SNT-TC-1A
Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

ASTM (ASTM International)
E164
Standard Practice for Contact Ultrasonic Testing of Weldments

CGSB (Canadian General Standards Board)
48.9712
Non-Destructive Testing – Qualification and Certification of NDT Personnel

CSA (Canadian Standards Association)
Z245.11
Steel Fittings

Z662
Oil and Gas Pipeline Systems

Government of the United States of America
Code of Federal Regulations (CFR) Title 49, Part 195
Transportation of Hazardous Liquids by Pipeline

ISO (International Organization for Standardization)
9001
Quality Management Systems

1.9 Quality Systems (Substitution)

Approved Manufacturers shall have quality programs in place in compliance with Appendix A, Quality System Program, and all related additional requirements specified in this SS.

1.9.1 General (Addition)

1.9.1.1

The Manufacturer shall have in place a documented quality management system in conformance with the requirements of ISO 9001 or another effective formal documented quality management system as approved by the Company.

1.9.1.2

The Manufacturer’s quality representative is responsible for advising the Company when conditions exist that adversely affect the bending operation with respect to surface preparation, material application, or performance so that immediate corrective measures may be initiated.

1.9.2 Inspection and Test Plans (ITP) (Addition)

The Manufacturer's ITP (or equivalent) shall be submitted for written approval by the Company at least one month before the start of bend manufacture (including test bend production), along with all referenced Manufacturer procedures, practices, and acceptance criteria. If indicated in the PO, a pre-production meeting shall be scheduled by the Vendor with Company representatives to review the required documentation and any specific project requirements.

1.9.3 Manufacturing, Inspection, and Testing Schedule (Addition)

The Manufacturer shall provide the Company with a current manufacturing, inspection, and testing schedule (or equivalent) at least one month in advance of the start of any such activities to permit mobilization of the Company's QA representatives.

1.9.4 Traceability of Materials, NDE, and Inspection Records (Addition)

The Manufacturer shall maintain written records with sufficient detail to permit full traceability of each bend to the starting material (including original heat number and pipe number) and to all procedures, production records, and quality records relating to forming, heat treatment, NDE, visual inspection, mechanical testing, and certification. All records shall be available to the Company for review.

1.9.5 Measuring Devices (Addition)

All adjustable measuring and testing devices shall be calibrated in accordance with standards traceable to the National Institute of Standards and Technology (NIST) or equivalent. Non-adjustable measuring devices such as rulers, squares, protractors, and tape measures shall be verified for good working conditions at a minimum of once per shift.

1.9.6 Company Rights (Addition)

The Company has the following rights:

a) To monitor, audit, or witness all or any aspects of manufacture, including steel making, casting, forging, rolling, forming, heat treatment, chemical testing, mechanical testing, visual and dimensional inspection, NDE, coating, certification, packaging, and shipping

b) To review the Manufacturer's QA/QC program and any or all quality-related records and test specimens associated with the activities described in item a), above

c) To reject any product that does not comply with this specification, applicable referenced codes, standards and specifications, specification datasheets, or other purchasing documents

1.9.7 Non-Conformance Reports (NCR) (Addition)

Any NCR raised by the Manufacturer shall be immediately reported to the Company (along with proposal for disposition) in a format acceptable to the Company. NCRs shall be uniquely and sequentially numbered for each occurrence and tracked on an NCR log. At the discretion of the Company, proposed disposition of NCRs may or may not be accepted.

1.10 Glossary

1.10.1 Abbreviations (Addition)

The following abbreviations are applicable to this document only:

CMTR	Certified material test report
EW	Electric welded
HAZ	Heat-affected zone
ITP	Inspection and test plans
LPI	Liquid penetrant inspection
MPI	Magnetic particle inspection
NCR	Non-conformance reports
NDE	Nondestructive examination
NGL	Natural gas liquid(s)
OD	Outside diameter
PBHT	Post-bend heat treatment
PD	Parent document
PO	Purchase order
PQ	Procedure qualification
Q&T	Quenched and tempered
QA	Quality assurance
QBP	Qualified bend procedure
QC	Quality control
SAW	Submerged-arc welding
SS	Supplementary specification
TMCP	Thermo-mechanically controlled processed
TSDR	Technical Standards Deviation Request

1.10.2 Definitions (Addition)

1.10.2.1 Technical Definitions

The following definitions are applicable to this document only:

Procedure qualification (PQ)
The test bend and associated nondestructive and destructive test data required to produce a QBP

Qualified bend procedure (QBP)
The procedure specified to produce an induction bend meeting the requirements outlined in this specification and associated specification datasheets

1.10.2.2 Defined Parties

The following definitions are applicable to this document only:

Company
The term "Company" shall hereafter refer to Enbridge Inc. and its representatives.

Manufacturer
The term "Manufacturer" shall hereafter refer to any and all involved parties that manufacture the equipment and products.

Purchaser
The term "Purchaser" shall hereafter refer to the Company's procurement or purchasing department.

Vendor
The term "Vendor" shall hereafter refer to any and all involved parties that supply and distribute the equipment and products.

1.10.2.3 Keywords

The following definitions are applicable to this document only:

May
Used to express an option or that which is permissible within the limits of the document

Shall
Use to express a mandatory requirement

Should
Used to express a recommendation or that which is advised but not required

1.11 Ordering Information (Substitution)

Omission
Nonmandatory Appendix B is provided as one possible guideline for providing the required information.

Insertion
The datasheet specified in Appendix B of the supplementary specification (SS) shall be used to provide the required information.

1.11.1 (Addition)

Pipe for induction bending may be supplied by the Manufacturer or the Company. Where materials are supplied by the Manufacturer, mill certificates stating the chemical and mechanical properties of the steel used in the manufacture of starting pipe shall be provided to the Company for review and acceptance. In either case the starting materials shall comply with Section 5.1.4 of this specification.

1.11.2 (Addition)

The QBP shall be submitted for the Company's review and acceptance prior to test bends being made.

1.11.3 (Addition)

The PQ and final QBP shall be submitted for the Company's review and acceptance prior to start of production bending.

1.11.4 (Addition)

The Manufacturer shall confirm the maximum expected wall thinning due to bending at the time of quotation.

2 Pressure Ratings

3 Size

4 Marking

4.1 Standard Marking (Modification)

k) Final markings of bends larger than NPS 16 shall be stencilled on both the inside and outside of the bend

l) Bends shall be marked with unique bend identification numbers, which shall be traceable to pertinent material certificates, test records, and inspection reports

4.1.1 (Addition)

All markings shall be applied clearly and legibly using a letter size and shape that permits easy reading. Where bends are supplied in the coated condition, paints used for stencils and colour codes shall be compatible with the coating but contrasting in colour.

4.1.2 (Addition)

The Manufacturer shall identify pipe segments reserved for the Company using an indelible marker with pipe numbers and heat numbers or other information that shall permit traceability to the original pipe and heat numbers.

4.2 Depth of Stamping (Modification)

Die stamping shall not be permitted.

4.4 Colour-Coding (Addition)

Where a colour code is specified on the specification datasheet, the Manufacturer shall apply one of the following:

a) A 25 mm (1 in.) circumferential paint band to the outside surface within 100 mm (4 in.) of one butt-welding end

b) A 25 mm (1 in.) diameter paint daub on the outside surface adjacent to the bend identification number

5 Material

5.1 Starting Materials

5.1.3 (Addition)

Induction bends made from seamless or straight seam welded pipe are preferred by the Company. Where it is necessary to use helical welded pipe to manufacture bends, the Manufacturer shall indicate this in writing and shall advise the Company at the time of the bid if problems are anticipated. In addition, Company approval shall be obtained through the TSDR process for all induction bends manufactured from cylinders. The Manufacturer shall ensure that appropriate precautions are taken to minimize manufacturing problems such as weld cracking on the extrados due to weld bead profile. Additional requirements beyond this specification may be applied when manufacturing induction bends from helical welded pipe or from cylinders.

5.1.4 (Addition)

Starting materials shall also comply with EES100, EES101, EES102, or EES103, whichever is applicable.

5.1.5 (Addition)

Starting materials for bends intended to be used in Canada shall additionally comply with Section 5 of CSA Z662 and CSA Z245.11.

6 Material for Bends Containing Welds

6.1.4 (Addition)

For side bends manufactured from straight seam welded pipe, the longitudinal seam shall be located in the top quadrant if it is not possible to locate it at the twelve o’clock orientation. For sag or overbends, the weld seam shall be located in the top half if it is not possible to locate it at the three o’clock or nine o’clock orientation.

6.1.5 (Addition)

To ensure correct orientation of the weld seams identified above, the following precautions shall be undertaken:

a) Where the nominal thickness of the matching pipe is different on each end, this shall be specified in the bend datasheet.

b) For side bends, the bend direction (right/left) shall be specified in the datasheet.

6.2 Girth Welds (Substitution)

Bending through a girth weld or skelp end weld shall not be permitted.

7 Chemical Composition (Modification)

Additional chemical composition requirements of starting materials are required by Company specifications per Section 5.1.3.

8 Material Properties

8.2 Fracture Toughness Properties

8.2.1 Testing Machine Capacity (Addition)

8.2.1.1

The testing machine capacity shall be adequate for the testing of full-size specimens or the largest size possible (as applicable) at the required test temperature.

8.2.1.2

Company approval shall be required to use less than full-size test specimens on account of expected energy values exceeding the working capacity of the Vendor's testing machine and shall be obtained through the TSDR process.

8.2.2 Reports (Addition)

Reports shall include absorbed energy, shear area, lateral expansion, and the test temperature.

8.3 Hardness Testing (Modification)

A surface macrohardness test shall consist of three readings at the location. The average value for each area shall be used as a reference value during hardness testing of production bends as required by Section 11.2 of ASME B16.49-2012.

9 Heat Treatment

9.4 Heat Treatment Records (Addition)

Each post-bend heat treatment time/temperature cycle shall be continuously recorded and documented in a manner that is traceable to each heat-treated bend. This is required for both qualification and production bends. Heat treat records shall be included with the certified material test report (CMTR).

9.5 Quenched and Tempered or Thermo-Mechanically Controlled Pipe (Addition)

The Manufacturer shall carefully consider the necessity of performing PBHT when Q&T or TMCP pipe is used for manufacturing bends. PBHT may have detrimental effects on the mechanical properties of the bends. The Manufacturer is responsible for ensuring that the bends will meet the required mechanical properties, with or without PBHT.

10 Qualification Bend

10.2 Records

10.2.1 Bend Qualification Procedure (Modification)

Bend qualification procedures and associated records shall be submitted for the Company's approval prior to the start of production.

11 Test Requirements (Modification)

The test bend shall be a minimum of 1,000 mm (39 in.) in length.

11.1 Qualification Bend Requirements (Addition)

The mechanical and metallurgical properties of the representative test bend that is from the same heat and has been subjected to the same thermal and mechanical treatments as required for production bend manufacture shall be determined at the locations identified in ASME B16.49-2012, Figure 2 or 3, and shall meet the requirements of Section 8 of this specification and the additional requirements of this section.

11.1.1.1 Test Specimen (Addition)

Transverse body and weld tension tests shall represent the full wall thickness of the bend and shall be conducted on rectangular strip specimens. Warm or hot flattening of test specimens shall not be permitted.

11.1.3 Weld Testing (Modification)

c) For electric welded (EW) seams in bends larger than NPS 12, Charpy V-notch impact specimens notched not more than 3.2 mm (0.125 in.) from the weld seam centreline shall be tested. The absorbed energy of EW seam Charpy tests shall meet the requirements of this specification and shall be reported to the Company.

11.1.4.1 Vickers Hardness Testing (Addition)

Qualification bends shall also be Vickers hardness tested on one specimen representative of each of the locations cited in Table 4 of this specification. The number and location of the hardness indentations on each specimen shall be as shown in figures 5A, 5B, and 5C of this specification. The maximum hardness shall not exceed 300 HV, using a 10 kg (22 lb.) load. Variations from the specified test methods shall be subject to Company approval prior to testing.

11.1.5 Exemption from Additional Testing Requirements of Table 4 (Addition)

Where the entire length of the starting pipe, including tangents, is subject to an uninterrupted induction heating and cooling cycle (i.e., no intermediate stops or starts) and any subsequent post-bend heat treatment, testing of the tangent sections as specified in Table 4 of this specification is not required. These induction bends will not have transition zones, and testing of the transition zones is also not required.

11.1.6 Weld and HAZ Tests (Addition)

Weld metal and HAZ test specimens shall be etched before notching to enable proper placement of the notches. Weld metal notches shall be located on the deposited weld metal centreline. HAZ notches shall be located predominantly in the heat-affected zone as close as practical to the fusion line.

11.1.7 Guided Bend Tests (Addition)

Welds in the bend region and, when the bend has been subject to post-bend heat treatment, in the tangent region shall be subjected to guided bend tests.

11.4 Mechanical Test Failures (Addition)

The Company shall be immediately notified of any mechanical test failures (for both qualification and production bends). Test results for the failed tests and the results of any required retests shall be provided to the Company.

12 Dimensional Requirements

12.2 Outside Diameter (Substitution)

Omission

The diameter throughout the bend and the remainder of the tangents need only meet the ovality tolerance unless the Purchaser and Manufacturer agree to other tolerances.

Insertion

The outside diameter along any point of a completed bend and the remainder of the tangents shall not be reduced by more than 2.5% of the specified nominal outer diameter and shall comply with the ovality requirements.

12.3 Wall Thickness (Modification)

The wall thickness at any point on the bend shall not fall below the minimum value specified in the bend datasheet.

12.5 End Preparation (Substitution)

12.5.1 Equal Thickness

For bends required to be welded to pipe/components of equal thickness, welding ends shall be machine bevelled in accordance with CSA Z662 Figure 7.1 or ASME B31.4 Figure 434.8.6-1, as applicable.

12.5.2 Unequal Thickness

12.5.2.1
For bends required to be welded to pipe/components of unequal wall thickness, welding ends shall be machine bevelled in accordance with CSA Z662 Figure 7.2 or ASME B31.4 Figure 434.8.6-(2), except where the nominal thickness of the matching pipe and the bend tangent differ by more than 1.6 mm (0.063 in.), in which case the tangent shall be counterbored and tapered to the nominal thickness of the matching pipe. The counterbore shall be a minimum of 200 mm (8 in.) in length, and the taper shall be at a 4:1 slope.

12.5.2.2
Where there is a requirement for the counterbore and taper operations to be performed in the field (and therefore are not in the Manufacturer's scope of work); this shall be indicated in the PO.

12.7 Tangents (Addition)

12.7.1 General
Where tangents are required, the minimum tangent length shall be 600 mm (24 in.) or as specified in the specification datasheet. The Manufacturer may propose alternate tangent lengths to optimize pipe usage.

12.7.2 Weld Reinforcement
Tangents shall have outside weld reinforcement removed for an axial distance of 100 mm (4 in.) minimum from both ends such that the weld beads do not extend above the pipe surface by more than 0.2 mm (0.008 in.). Where tangents are not counterbored and tapered, the inside weld reinforcement shall also be removed.

12.8 Bend Cut-offs (Addition)
Straight pipe segments at least 1,000 mm (39 in.) in length leftover after mechanical testing or cutting bends to required dimensions shall be identified and reserved for use by the Company. Marking of such pipe segments shall be in accordance with Section 4.1.

13 Inspection of Production Bends

13.1 Workmanship and Finish (Substitution)

Omission
Repair by welding of base metal or weld metal is not permissible without Purchaser approval.

Insertion
Repair by welding shall not be permitted. Bends that show evidence of buckling shall be rejected. Where grinding is performed, the surface shall be ground to a surface finish of 3.2 μm (0.00013 in.) or finer. All ground surfaces shall be inspected using liquid penetrant or magnetic particle inspection methods.

13.2 Nondestructive Examination (Substitution)

Omission
The entire extrados of each bend, from neutral axis to neutral axis including the weld seam, shall be magnetic particle or liquid penetrant examined for injurious defects.

Insertion
The entire circumference of the finished bend, including any tangent sections when such sections are subject to induction heating and cooling, shall be examined by liquid penetrant or magnetic particle inspection methods for injurious defects.

13.2.1 Welds in Bends (Addition)

13.2.1.1
All longitudinal welds in bends NPS 18 and larger shall be subject to film radiographic or ultrasonic examination throughout the induction heated zone after bending (and PBHT when required) according to approved documented procedures. Welds shall meet the requirements of the applicable pipe specification or, where cylinders are provided by the bend Manufacturer, ASME/BPVC SEC VIII-1.

13.2.1.2
For helical pipe, the weld seam on the extrados of the bend shall be examined. For the purposes of this section, the extrados shall extend from the top to the bottom neutral axis.

13.2.2 Visual Inspection (Addition)

13.2.2.1
The bend shall be visually examined to detect any irregularities in curvature that may indicate hard spots or other detrimental conditions. Hardness at such locations shall comply with the requirements of ASME B16.49 and Section 8.3 of this specification.

13.2.2.2
Slivers, scabs, bristles, or other surface imperfections that could result in an unacceptable applied coating shall be considered as defects and removed by grinding or by other means acceptable to the Company.

13.2.3 Weld Bevels (Addition)
Weld bevel faces shall be inspected after final machining by liquid penetrant or by magnetic particle inspection methods. Any indication with a dimension in excess of 6.4 mm (0.25 in.) or an accumulation of 6.4 mm (0.25 in.) in any 50 mm (2 in.) sector shall be removed. Repair welding of bevels shall not be permitted.

13.2.4 Ultrasonic Inspection (Addition)

Where an ultrasonic inspection is performed, suitable pulse-echo instruments with verified operating characteristics acceptable to the Company shall be used. The ultrasonic inspection procedure shall be in accordance with ASTM E164. Transducers shall be shaped according to pipe OD per the requirements of ASTM E164 and shall operate at a frequency of 2 to 5 MHz. Shear wave inspections shall be performed by the use of 45° and 60° or 45° and 70° transducers. During laminar inspections, if indications are noted, probe diameter may have to be adjusted to best detail the indication size and profile. Calibration blocks, standards, and procedures shall be subject to Company approval.

13.2.5 Personnel Qualifications (Addition)

NDE personnel performing interpretation of results shall be certified to CGSB 48.9712 Level II, ASNT SNT-TC-1A Level 2, or equivalent for the specific inspection method.

14 Certification (Modification)

j) Unique bend number

k) Starting pipe number

l) Source of material

m) Bend dimensions

n) Heat treatment process and records

o) Heat analysis

p) Product analysis

q) Guided bend test results

r) Radiographic test results

s) LPI test results

t) MPI test results

u) Visual test results

v) All other applicable chemical and mechanical test results

14.1 Certified Material Test Report (CMTR) (Addition)

14.1.1

The Manufacturer shall provide the Company with CMTRs signed by an authorized agent of the Manufacturer. CMTRs shall include the unique bend number, starting pipe number, heat treatment records, bend dimensions, and all applicable chemical and mechanical test results.

14.1.2

The product shall not be released for shipment prior to the Company's review and written acceptance of final CMTRs and any other required documents.

SR15 Supplementary Requirements

SR15.3 Segmentable Bends (Modification)

Where specified in the specification datasheet, induction bends shall meet the requirements for segmentable bends as specified in ASME B16.49. The Manufacturer's proposed methods for complying with these requirements shall be subject to the prior approval of the Company in writing.

16 Coating (Addition)

Bends shall be supplied in bare, uncoated condition unless otherwise indicated in the purchasing documents. If coating is specified, coatings shall be selected and applied in accordance with the Company's coating specifications.

17 Shipping (Addition)

17.1 Protection

All bends shall be handled and shipped using sufficient protection to prevent abrasion and impact damage. Open ends shall be covered with securely attached covers or caps. No tack welding shall be allowed for attachment of any protective device. The Company shall approve shipping methods. Transit damage shall be reason for rejection of bends.

17.2 Inspection of Company-Supplied Pipe

All pipe shall be inspected by both the Company and the Manufacturer for quality and condition upon receipt. The Manufacturer's inspection record (signed by the Company) shall determine the amount of pipe delivered to the Manufacturer by the Company.

17.3 Dunnage

Dunnage shall be made from oak wood or equivalent hardwood and shall conform to the dimensions specified in sections 17.3.1 and 17.3.2.

17.3.1 Chocks

Chocks shall be 100 mm wide x 150 mm high (4 in. wide x 6 in. high) with a 32° angle for pipe less than NPS 42 OD and a 45° angle for pipe less than NPS 18 OD. Chocks for all other diameters shall be cut at an angle to ensure maximum contact of the entire angled surface with the pipe. In no case shall plastic chocks be permitted. Nails used to secure the chocks shall be driven perpendicular to the plane of the angle side of the chock securing the chock to the bolster. Nails shall be driven outside the pipe contact area and shall be countersunk a minimum of 3 mm (⅛ in.).

17.3.2 Bolsters

Bolsters shall be 50 mm x 150 mm (2 in. x 6 in.) and 2,450 mm to 2,600 mm (8 ft. to 8 ft., 6 in.) in length. Four bolsters per layer per load shall be used and shall be padded with 6 mm (¼ in.) thick rubber padding with the securing nails placed outside the pipe contact area.

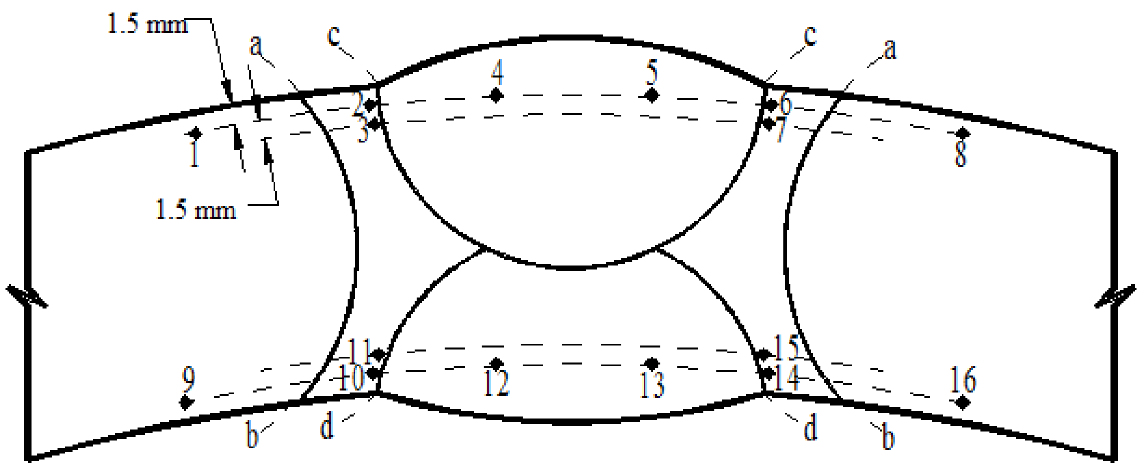
Table 4 – Mechanical and Metallurgical Test Locations for Qualification Bends (Addition)

Type of Test Required	Test Locations					
	Tangent (3,4)		Transition (3)	Intrados	Extrados	NA Weld (5,8)
	Body	Weld	Extrados	Trans.	Trans.	Trans.
Tensile test (6)	X	X	X (7)	X	X	X
Cross-section hardness test		X	X	X	X	X
Charpy impact test (1)	X	X	X	X	X	X
Guided bend test		X				X
Surface hardness test (2)	X	X	X	X	X	X

Table key: Trans. = transverse, NA = neutral axis, X = test required.

Notes:

1. The test temperature and minimum absorbed energy shall be as specified in the specification datasheet.
2. A minimum of three equally spaced hardness readings are required for each location. For additional information, see Section 8.3.
3. Testing is not required if tangents have been subjected to the same induction heating, cooling, and post-bend heat treatment as the bend. See Section 1.2 of ASME B16.49.
4. Testing is also not required in the case where the bend has not been post-bend heat treated.
5. In this table, weld test locations refer to both weld metal and heat-affected zone tests for hardness and Charpy impact testing.
6. On pipe smaller than NPS 8, body tensile tests shall be conducted using longitudinal specimens, and transverse weld tests are not required.
7. Tensile specimens shall be transverse to the transition zone (i.e., longitudinal specimens).
8. Where helical welded pipe is used, the specified weld tests shall also be conducted on helical weld in the intrados and extrados of the bend.
9. See figures 5A, 5B, and 5C for additional details.



a-b Boundary between the visible weld heat-affected zone and the unaffected parent metal (visible after etching)

c-d Boundary between weld metal and weld heat-affected zone (visible after etching); known as the fusion line or fusion boundary

Figure 5A – Vickers Hardness Traverse Across Weld (SAW) (Addition)

Notes:

1. Maximum load = 10 kg
2. Heat-affected zone hardness impressions 2, 3, 6, 7, 10, 11, 14, and 15 shall be located entirely within the heat-affected zone in the structure of maximum hardness. Typically this is within 0.5 mm (0.02 in.) of the fusion line. The line of survey shall be positioned so that impressions 2, 6, 10, and 14 coincide with the heat-affected zone of the final run or change of profile of the fusion line associated with the final run on each side of the weld.

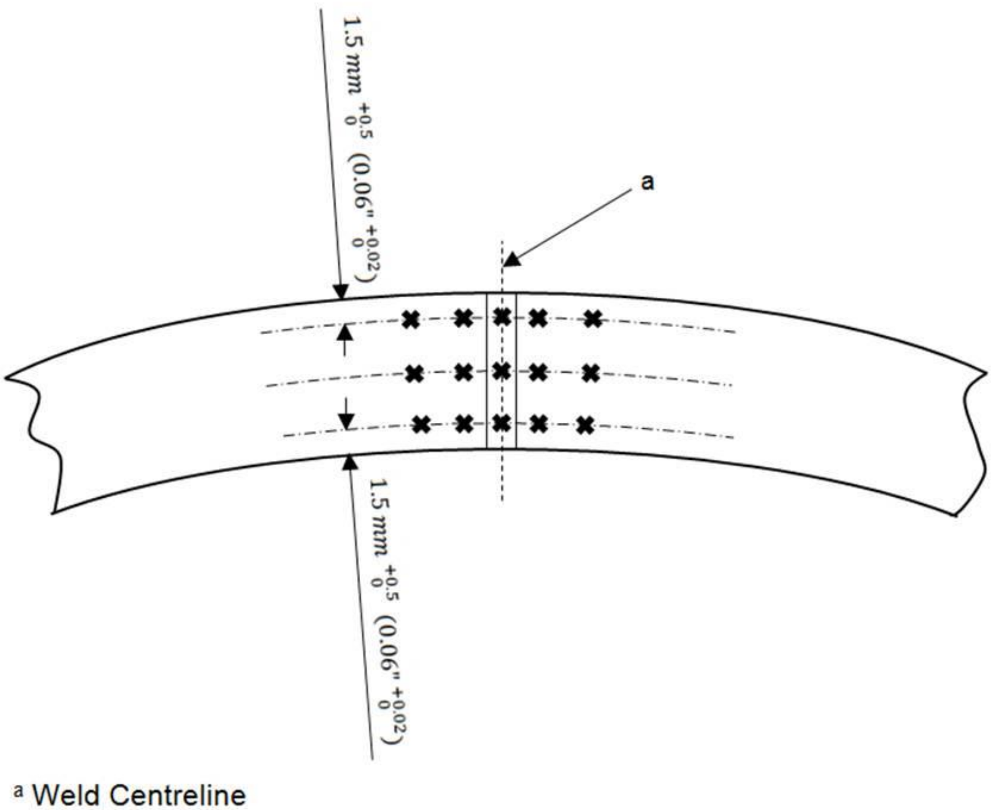


Figure 5B – Vickers Hardness Traverse across Body and Weld (EW) (Addition)

Note: For pipe with a specified wall thickness ≤ 0.219 in. (5.6 mm), a single hardness traverse shall be performed at the pipe mid-wall. For pipe with a specified wall thickness > 0.219 in. (5.6 mm), two traverses shall be performed, with one traverse near the inside surface and one traverse near the outside surface. The inside and outside traverses shall be performed at a distance not less than three impression diameters from the respective pipe surfaces. Each traverse shall consist of a reading in the weld, readings on each side of the weld in the heat-affected zone, and readings on each side of the weld in the unaffected parent material.

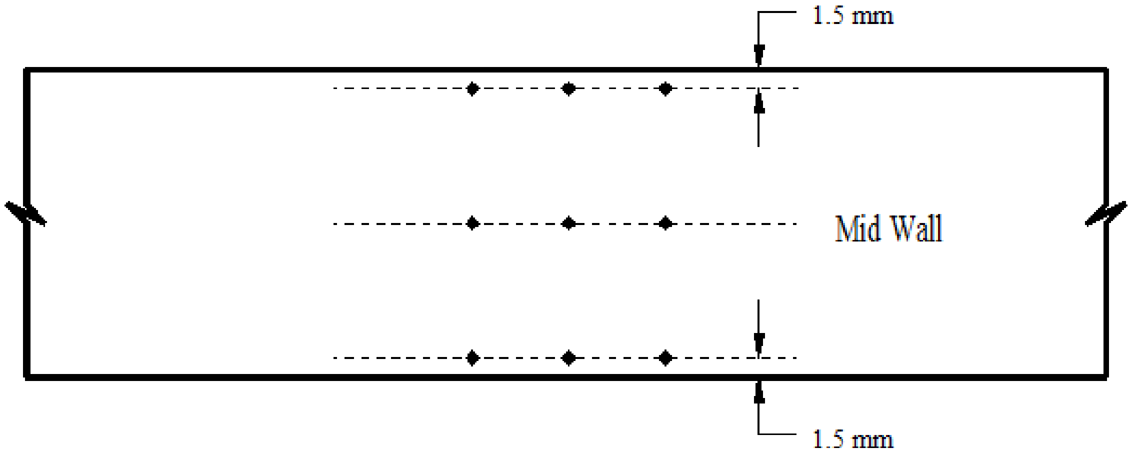


Figure 5C – Vickers Hardness Traverse across Body (Addition)

Note: maximum load = 10 kg, minimum of nine hardness readings

Appendix B
Specification Datasheet (Substitution)

Steel Pipe Induction Bends Specification Datasheet					
Project Information					
Project:	**Datasheet Number:**				
Project number:			YY/MM/DD XX		
Location: ☐ CAN ☐ US			YY/MM/DD XX		
Requisition #: Rev: TBD			YY/MM/DD XX		
Purchase order #:	REV	REV DESCRIPTION	DATE/BY	CHK	APP

A) General		
1.	Service/commodity	☐ Crude oil – sweet ☐ Crude oil – sour ☐ NGL
2.	Pipeline code	☐ CSA Z662 ☐ ASME B31.4
3.	Nominal pipe size	mm in.
4.	Design pressure	MPa psi
5.	Design temperature	°C °F
6.	Minimum design temperature	°C °F
7.	Corrosion allowance	mm inches
8.	Design factor	☐ N/A
9.	Location factor	☐ N/A
10.	Joint factor	☐ N/A
11.	Temperature correction	☐ N/A

B) Bend Data		
12.	Bend angle	degrees
13.	Bend orientation	☐ Side bend ☐ Sag ☐ Overbend
14.	Flow direction (side bend)	☐ Left ☐ Right
15.	Centreline radius	mm in.
16.	Tangent length	mm in.
17.	End preparation	CSA Z662 ☐ Fig. 7.1 ☐ Fig. 7.2 Sketch No. ASME B31.4 ☐ Fig. 434.8.6 (a)-1 ☐ Fig. 434.8.6 (a)-2 Sketch No. ☐ Other (end preparation details attached):
18.	Minimum wall thickness (post-bending)	mm inches

Steel Pipe Induction Bends Specification Datasheet					
Project Information					
Project:	**Datasheet Number:**				
Project number:			YY/MM/DD XX		
Location: ☐ CAN ☐ US			YY/MM/DD XX		
Requisition #: Rev: TBD			YY/MM/DD XX		
Purchase order #:	REV	REV DESCRIPTION	DATE/BY	CHK	APP

19.	ASME B16.49 supplementary requirements	☐ SR15.1 Heat Treatment ☐ SR15.2 Nondestructive Examination ☐ SR15.3 Segmentable Bends ☐ SR15.4 Fracture Toughness (refer to Section C, below) ☐ SR15.5 Sour Gas Applications ☐ SR15.6 Weld Seam Examination: UT ☐ SR15.7 Weld Seam Examination: RT ☐ SR15.8 Chemistries Details for supplementary requirements:
C)	**Impact Test Data**	
20.	Test temperature	°C °F
21.	Minimum absorbed energy	
22.	Body	Minimum each specimen Joules ft-lbf Average Joules ft-lbf
23.	Weld and HAZ	Minimum each specimen Joules ft-lbf Average Joules ft-lbf
24.	Shear area	☐ Per ASME B16.49 ☐ Other Minimum each specimen % Average %
D)	**Matching/Adjoining Pipe Data**	
25.	Nominal wall thickness (Note 3)	mm in. schedule
26.	Material specification (Note 1)	
E)	**Starting Pipe Data**	
27.	Supplied by	☐ Company ☐ Bend Manufacturer
28.	Nominal wall thickness	mm in. schedule
29.	Material specification (Note 1)	
30.	Thinning allowance (Note 2)	
F)	**Coatings**	
31.	External coating required	☐ Yes ☐ No Coating details, including Company specification number:
G)	**Additional Requirements**	
32.	Bevel protectors	☐ Plastic ☐ Metal ☐ N/A

Steel Pipe Induction Bends Specification Datasheet					
Project Information					
Project:	**Datasheet Number:**				
Project number:			YY/MM/DD XX		
Location: ☐ CAN ☐ US			YY/MM/DD XX		
Requisition #: Rev: TBD			YY/MM/DD XX		
Purchase order #:	REV	REV DESCRIPTION	DATE/BY	CHK	APP

Notes:

1. Examples of material specification callouts:
   a) API 5L Grade X52 PSL2 Q&T SAWL
   b) CSA Z245.1 Grade 359 CAT II (M29C) Q&T SAWL
2. This is the thinning allowance used in the design calculations when determining the minimum required wall thickness for the starting pipe. The Manufacturer shall confirm that the required thinning allowance does not exceed this number.
3. Specify wall thickness of matching pipe at both ends of the bend if different.

Appendix C
Vendor Documentation Datasheet (Addition)

Steel Pipe Induction Bends Vendor Documentation Datasheet			
Vendor:		MR/RFQ number:	
Tag number(s):		Purchase order number:	
Equipment:		Revision:	

Item Code	Data/Document Type	With Quote	For Review after Award				Certified
		# of Copies (P/R)	# of Copies (P/R)	Doc. Due for Review (Weeks)	Weeks Promised (Note 1)	Company Approval Req'd Prior to Start of Fabrication	# of Copies
1 Commercial							
1.1	Seller's document index	-	1R	2 ARO		Yes	Note 2
1.2	Fabrication and delivery schedule	1R	1R	2 ARO		Yes	Note 1
1.3	Manufacturing location(s)	1R	-			Yes	-
2 Technical							
2.1	Specification datasheet (marked up)	1R	1R	2 ARO		Yes	Note 2
2.2	Verification of conformance to specification or a list of exceptions/deviations	1R	1R	2 ARO		Yes	Note 2
2.3	General arrangement drawings	-	1R	2 ARO		Yes	Note 2
2.4	Dimensioned outline drawings	1R	1R	2 ARO		Yes	Note 2
2.5	Shipping weights and dimensions	-	1R	6 ARO		-	Note 2
2.6	Material certificates (MTRs)	-	1R	2 ARO		Yes	Note 2
2.7	Material specifications for all components	-	1R	2 ARO		-	Note 2
2.8	Packing, shipping and storage procedures	-	1R	6 ARO		-	Note 2
2.9	NDE reports	-	1R	AT		-	Note 2
2.10	Qualification bend test report	-	1R	AT		-	Note 2
2.11	Painting and coating reports	-	1R	AT		-	Note 2
2.12	Post-bend heat treatment report	-	1R	AT		-	Note 2
3 Quality							
3.1	Quality manual table of contents	1R	1R			Yes	Note 2
3.2	Inspection and test plan (ITP)	-	1R	2 ARO		Yes	Note 2
3.3	Impact test procedure (Charpy)	-	1R	2 ARO		-	Note 2
3.4	Hardness test procedure	-	1R	2 ARO		-	Note 2
3.5	NDE procedures	-	1R	2 ARO		-	Note 2
3.6	Surface preparation, painting and coating procedures	-	1R	2 ARO		-	Note 2

Steel Pipe Induction Bends Vendor Documentation Datasheet			
Vendor:		MR/RFQ number:	
Tag number(s):		Purchase order number:	
Equipment:		Revision:	

Item Code	Data/Document Type	With Quote	For Review after Award				Certified
		# of Copies (P/R)	# of Copies (P/R)	Doc. Due for Review (Weeks)	Weeks Promised (Note 1)	Company Approval Req'd Prior to Start of Fabrication	# of Copies
3.7	Certificate of compliance with specifications and drawings	-	1R	2 ARO		-	Note 2
3.8	Certified material test report (CMTR)	-	1R	AT		-	Note 2
4 Final Vendor Data Book							
4.1	Final Vendor data book	-	2P,1R	AS		-	Note 3

Legend:
P = Print (all prints greater than 11 x 17 in. must be folded to 8 ½ x 11 in.)
R = Reproducible (drawings in CAD format, documents in PDF)
ARO = after receipt of order
AT = After testing
AS = After shipment
AP = After placement

Notes:
1. The Vendor shall confirm the submittal schedule at the time of proposal.
2. The final copy shall be submitted as part of the final Vendor data book.
3. One paper copy of the Final Vendor data book shall be shipped with the equipment.

Appendix D
Minimum ITP Requirements (Addition)

The requirements shown in Table D.1 shall be incorporated in the Vendor's ITP.

Table D.1 – Minimum ITP Requirements

Item	Activity	Notes	Criteria	
			Company	**Vendor**
1	ITP preparation and review	Confirm the ITP is submitted and reviewed as a Code 1 or 2 document prior to fabrication.	H	H
2	Review of all construction material	Verify the materials to be used prior to the start of fabrication.	R	R
3	Critical dimension verification	Confirm the dimensions meet the requirements specified in the drawings.	R	R
4	Review and approve induction bending procedures	Review bending procedures, post-bending treatment, and bending acceptance criteria.	R	R
5	Non-destructive examination (NDE)	Review NDE for bend qualification.	R	R
6	Fabrication/Production Testing	Review and approve charpy impact test results (if applicable).	R	R
		Review and approve hardness test results.	R	R
		Verify results from the bending laboratory tests.	R	R
		Witness testing of qualification bends.	W	W
7	Painting and coating	Visually inspect the surface preparation prior to coating.	H	H
		Monitor coating inspection (thickness and holiday test.)	H	H
		Check dimensions and review coating quality verification documents.	H	H
8	Final inspection	Verify all inspection activities are complete.	H	H
		Verify that all materials of construction are per the drawings and specifications.		
		Visually inspect the completed package for compliance with specifications. Inspect general workmanship.		
		Verify the final Vendor data book is complete. Review documents for correctness, legibility, and traceability.		
		Verify marking, tagging, and preparation for shipment.		
9	Release for shipping	Issue release for shipping upon satisfactory completion of quality surveillance activities.	H	H

Legend:

R Review (R) is an activity where the work practice or installation technique or documentation is reviewed. This can be performed at any stage of the activity and does not require scheduling or prior notification. If the Company does not review the work at this point, work may continue.

W A witness point (W) is an activity during the manufacturing or construction phase where the inspection, measurement, or test shall be done in place and documented. The Vendor shall provide written notice to the Company in advance of all witness points. Work shall not proceed past the witness point unless the Company waives the witness point. This waiver shall be in writing and shall be received prior to the inspection execution.

H A hold point (H) is an activity during the manufacturing or construction phase where the inspection, measurement, or test shall be done in place and shall be witnessed by the Company and, where required, a regulatory authority. The Contractor shall provide written notice to the Company in advance of all hold points. Work shall not proceed past the hold point until the inspection, measurement, or test has been witnessed and approved by all parties.

Submerged-Arc-Welded Steel Pipe

Supplementary to API 5L

EES103 – (2013)

Enbridge Pipelines Inc.

Enbridge Energy Partners L.P.

Revision: 2.0
Effective Date: November 29, 2013

Management of Change

1 Revision Summary

Revision	Description
2.0	Complete revision All sections reviewed and updated as necessary.

2 Applicability

Revision	Description	Effective Date
2.0	This revision is applicable to all projects that have not received AFE approval. Projects with AFE approval shall continue to abide by the previous revision. If projects with AFE approval choose to adopt the latest revision of the standard, a Project Decision Record is required.	November 29, 2013

Please see Section 19 – Revision History for a list of significant changes.

Table of Contents

1 Scope

This specification covers requirements for the manufacture, qualification, inspection, and testing of submerged-arc-welded steel pipe for transportation of onshore, non-sour service hydrocarbon fluids under stress-based design in grades from L245 (Grade B) to L485 (X70). This specification supplements the requirements of API 5L, forty-fourth edition and is to be used in conjunction with that specification (including all applicable published Annex N addenda).

For continuity, clause numbers in this specification that supplement API 5L requirements follow the same sequence and primary headings as API 5L, forty-fourth edition, Addendum 3. Sections not addressed in this specification are governed exclusively by API 5L. Additional clauses covering subjects not addressed by API 5L have been inserted in sequence. Where there is a conflict or discrepancy between any applicable codes and the content of this specification, the most stringent requirement shall apply.

Pipe shall be supplied to meet this specification, the specification datasheet, and the edition of API 5L cited in 49 CFR Part 192 or 49 CFR Part 195 in effect at the time of production.

Any planned deviations from this specification shall be submitted to the Company prior to the awarding of a purchase order. To receive consideration, planned deviations shall represent fundamental process limitations, not merely cost savings opportunities. Approvals for any planned deviations are specific to the purchase order and shall be obtained from the Company in writing prior to production.

Pipe shall meet the level of technical requirements designated as product specification level (PSL) 2.

For the purchase of small quantities of stock (off-the-shelf) pipe and in other circumstances at the discretion of the Company, the full requirements of this specification may be made subject to the provisions of Annex R only. This shall be identified in the specification datasheet if it is the case.

In this document, the term “Company” shall hereafter refer to Enbridge Inc. and its representatives.

The term “Inspector” shall hereafter refer to the Company field or shop representative responsible for performing inspections.

The term “Manufacturer” shall hereafter refer to any and all involved parties that manufacture the equipment and products.

The term “Vendor” shall hereafter refer to any and all involved parties that supply, distribute, and manufacture the equipment and products.

2 Conformity

2.1 Units

The units to be used on mill test reports (MTRs), pipe stencil information, and all supporting documentation submitted to the Company shall be per the specification datasheet.

2.3 Compliance to This International Standard

2.3.1

All pipe manufacturing facilities shall have an API Q1 certified quality management system to the specification API 5L. All coil/plate feedstock manufacturing facilities and third-party companies used for qualification testing (if applicable) must have an ISO 9001 certified quality management system or an equivalent deemed acceptable by the Company. Third-party distributors of stock pipe sourcing pipe to the Company (if applicable) must have an ISO 9001 certified quality management system or an equivalent deemed acceptable by the Company. At the discretion of the Company, a QMS audit may be performed by the Company before, during, or after production.

3 Normative References

The following resources are referenced in this document, and unless otherwise indicated, the latest edition shall apply.

49 CFR Part 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
49 CFR Part 195	Transportation of Hazardous Liquids by Pipeline
AAR OTLRM Section 2	Rules Governing Loading of Steel Products Including Pipe on Open Top Cars
API RP 5L1	Recommended Practice for Railroad Transportation of Line Pipe
API RP 5LW	Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels
API STD 1104	Welding of Pipelines and Related Facilities
API Q1	Specification for Quality Programs
ASME B16.49	Factory-Made, Wrought Steel, Buttwelding Induction Bends for Transportation and Distribution Systems
ASME/BPVC SEC IX	Section IX Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators
ASNT-SNT-TC-1A	Recommended Practice for Personal Qualification and Certification in Nondestructive Testing
ASTM A435	Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates
ASTM A578	Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications
ASTM E4	Standard Practices for Force Verification of Testing Machines
ASTM E23	Standard Test Methods for Notched Bar Impact Testing of Metallic Materials

ASTM E384	Standard Test Method for Knoop and Vickers Hardness of Materials
ISO 9001	Quality Management Systems
ISO 10893	Non-Destructive Testing of Steel Tubes
ISO 11484	Steel products – Employer's Qualification System for Non-Destructive Testing (NDT) Personnel

3.1 Minimum Federal Safety Standards

Pipe supplied to this specification is intended for installation in a pipeline constructed as specified by 49 CFR Part 192 and 49 CFR Part 195. Pipe shall meet the applicable requirements of those regulations, API 5L, forty-fourth edition, and this specification.

4 Terms and Definitions

4.68 Crack

A discontinuity characterized by a sharp tip and high ratio of length and width to opening displacement

4.69 Specification Datasheet(s)

Information issued to the prospective Manufacturer in a format as outlined in Annex Q of this specification provided with the call for tenders and the purchase order

5 Symbols and Abbreviated Terms

5.2 Abbreviated Terms

AAR	Association of American Railroads
API	American Petroleum Institute
ASME	Association of Mechanical Engineers
ASTM	American Society for Testing and Materials
CE	Carbon equivalent
CVN	Charpy V-notch
DWT	Drop-weight test
ECA	Engineering critical assessment (as defined by API 1104 Annex A)
ID	Inside diameter
LPI	Liquid penetrant inspection
MPI	Magnetic particle inspection
MPS	Manufacturing procedure specification
MTR	Mill test report

NDE	Nondestructive examination
NIST	National Institute of Standards and Technology
OD	Outside diameter
OOR	Out-of-roundness
PQR	Procedure qualification record (as defined by ASME/BPVC Section IX)
PSL	Production specification level
QA	Quality assurance
QC	Quality control
QMS	Quality management system
RT	Radiographic testing
SAW	Submerged-arc welding
SAWH	Submerged-arc helical welding process for pipe during manufacture
SAWL	Submerged-arc longitudinal welding process for pipe during manufacture
SMYS	Specified minimum yield strength
UT	Ultrasonic testing
WPS	Weld procedure specification
WT	Wall thickness
Y/T	Yield to tensile strength ratio
HAZ	Heat affected zone

6 Pipe Grade, Steel Grade, and Delivery Condition

6.2 Delivery Condition

6.2.3

No subsequent heat treatment shall be performed with the intention of modifying mechanical properties unless included in the approved MPS.

8 Manufacturing

8.1 Process of Manufacture

8.1.1 Manufacturing Procedure Specification

The Manufacturer shall submit with the quotation a manufacturing procedure specification in conformance with Annex B (minus those items indicated as being order specific). If the Manufacturer has supplied the Company with pipe to this specification in the past, any revisions to these items must be summarized and referenced at the beginning of the document.

The Manufacturer shall submit, prior to slab production, any order-specific items identified as such in Annex B.

The Company shall be notified in writing of any proposed changes to the MPS prior to or during production.

8.3 Starting Material

8.3.10 Internal Slab Quality

The Manufacturer shall have a documented process for controlling slab internal quality.

8.3.11 Surface Cleanliness (In Process)

The Manufacturer shall maintain sufficient surface cleanliness for inspection purposes. Where necessary, plate, skelp, or pipe may be cleaned either by shotblasting or sandblasting.

8.4 Tack Welds

8.4.3

All evidence of tack welds shall be removed by the submerged-arc weld or by repair welding per C.4.

8.6 Weld Seams in SAW Pipe

8.6.1 Flux and Wire Qualification

Welding procedures for the longitudinal, helical, and circumferential jointer welds shall be qualified per ASME/BPVC SEC IX for each welding process and for each flux trade name/designation and electrode trade name/designation combination employed.

8.6.2 ASME/BPVC SEC IX Group Numbers

Group number (as defined by ASME/BPVC SEC IX) shall be designated an essential variable for qualification of welding procedures, regardless of impact toughness requirements.

8.6.3 ASME/BPVC SEC IX PQR Impact Testing

All supplementary essential variables per ASME/BPVC SEC IX shall apply. Procedure qualification testing shall include Charpy V-notch impact tests of the weld and heat-affected zone. The Charpy notch for the heat-affected zone shall be as close as practicable to the fusion line of the OD weld toe as shown in Figure 7 in Annex N. The absorbed energy requirements shall be per Clause 9.8.3.

8.6.4 Hardness Requirements

As part of the weld procedure qualification, weld hardness traverse tests are required for the pipe weld metal, parent metal, and heat-affected zone of longitudinal, helical, and circumferential jointer welds. Such tests shall include three microhardness traverses across the weld, heat-affected zones, and parent material. One traverse shall be within 2 mm (0.080 in.) of the outside surface, one traverse shall be at the mid-wall point, and one traverse shall be within 2 mm (0.080 in.) of the inside surface. All readings in each zone shall be performed on the hardest-appearing structure. The hardness in the weld, heat-affected zone, and base metal shall not exceed 300 HV_{500} when tested as specified by ASTM E384.

The results of all hardness tests shall be reported.

8.6.5 Inter-Pass Forming Strains (SAWH)

For SAWH pipes, pipe shall be fully formed prior to the application of the initial SAW pass in order to mitigate inter-pass forming strains.

8.6.6 Hydrogen Control in SAW Flux

The Manufacturer shall have detailed procedures for the control, mitigation, and monitoring of moisture levels in the weld flux. Procedures shall encompass verification of incoming flux, storage of flux on site, and storage in recirculating hoppers.

8.6.7 Repair Welds

Repair welds to the SAW weld seams are permissible in accordance with the requirements of annexes C and D of API 5L, forty-fourth edition and this specification. Repair welds to the pipe body are not permissible.

8.9 Cold Sizing and Cold Expansion

8.9.3

Where cold expansion is employed, the sizing ratio shall be calculated and reported using Equation (1) on one pipe per shift (at a minimum).

8.9.4 Weldment During Cold Expansion

Suitable provisions shall be incorporated to protect welds from contact with the expander when cold expansion is used.

8.10 Strip/Plate End Welds

Strip/plate end welds are not permissible in prime finished pipes.

8.11 Jointers

8.11.1

Where permitted in the specification datasheet, mill-jointers may be furnished within the limits of Clauses 8.11 and 9.11.3.3 (Annex N) of API 5L and Annex A of this specification.

8.13 Traceability

8.13.3 Materials Records

The material and process history of each pipe as delivered to the Company shall be traceable from the steel mill, through rolling and plate or coil production, through the pipe mill, through the physical and chemical testing labs, through any jointing processes, and through the coating mill (if applicable). The Manufacturer shall utilize and demonstrate positive pipe tracking (by individual pipe numbers) with records of disposition and rework (where applicable) through the hydroinspection station, the final ultrasonic inspection station, all repair/rework stations, and the final visual/dimensional inspection area. Provisions for traceability shall be described in the MPS.

The final report provided to the Company by the Manufacturer shall include confirmation that key process steps as defined by the MPS were performed on the product and shall also include detailed data and information as required by this specification. Any breaks in the traceability chain caused by unusual circumstances such as equipment breakdown or rework that is not part of the normal manufacturing process as described in the MPS shall be documented by the Manufacturer, along with a description of measures taken to preserve traceability and appropriate documentation to support the preservation of material traceability.

8.13.4 Welding Records

For all welds, including jointer and repair welds, the Manufacturer shall maintain detailed written records regarding the use of welding consumables (e.g., electrode batches, wire heats, and flux batches) and periodic measurement of welding parameters. Records shall be sufficient to permit tracing of weld procedures, consumable batches, and welding process parameters to the individual pipes produced and shall be available to the Company for review upon request.

9 Acceptance Criteria

9.2 Chemical Composition

9.2.2

The composition of steel for the pipe furnished to this specification shall conform to API 5L Table 5 and the following requirements:

Table 5.1 – Chemical Requirements

Factor	Symbol	Maximum %
Carbon equivalent	CE_{PCM}	Per Table 5
Carbon equivalent (regardless of carbon content)	CE_{IIW}	0.46
Element	**Symbol**	**Maximum % Element by Weight**
Carbon	C	0.12
Manganese	Mn	Per Table 5
Phosphorus	P	0.018
Sulphur	S	0.006
Silicon	Si	Per Table 5
Copper	Cu	0.40
Nickel	Ni	Per Table 5
Chromium	Cr	Per Table 5
Molybdenum	Mo	Per Table 5
Niobium	Nb	Per Table 5
Titanium	Ti	0.025
Vanadium	V	Per Table 5
Boron	B	0.0010
Nitrogen	N	0.012

Notes (Mandatory):

1. No deliberate additions of boron or nitrogen are permitted.
2. When ECA is required per the specification datasheet, the minimum allowable carbon content shall be 0.040 wt%.
3. If required per the specification datasheet, pipe intended for induction bending shall additionally meet the requirements of ASME B16.49 Table 2.

9.2.6 Additional Elements

The Manufacturer shall furnish a certified report showing the heat analysis for each heat of steel, which shall include all of the elements listed in Clause 9.2.2 of this specification as well as any other element intentionally added for any reason, including deoxidation, inclusion shape control, and transformation control.

9.2.7 Non-Conformances (Chemistry)

If any product value does not comply with the values in Clause 9.2.2 of this specification, all pipe and remaining plate or skelp made from that heat shall be rejected or the remaining pipe lengths processed from the remaining plate or skelp from that heat shall be individually checked.

9.2.8 Max Carbon and Pcm for Elements Requiring ECA

Where an ECA is required per the specification datasheet, a 24 m joint representing the highest Pcm carbon equivalent from the first 20 heat lots produced (or from the total order if the order item constitutes less than 20 heats) shall be supplied for each source slab producer and coil/plate processor. The carbon and Pcm value of the pipe supplied cannot be exceeded by more than 0.02 on the remaining heats allocated against the order item. Adherence to this clause shall be based on the heat (ladle) analysis only.

9.3 Tensile Properties

9.3.3 Qualification Test Location

The sampling location shall be taken from a location in the coil/mother plate conservative with respect to the mechanical properties being measured. This location shall be identified in the MPS.

9.3.4 Range of Yield Strengths

The range of actual yield strengths based on laboratory qualification testing shall not exceed 131 MPa (19,000 psi) for each pipe order of a specific diameter, wall thickness, and grade.

9.3.5 Yield to Tensile Strength Ratio

The ratio of yield strength to ultimate tensile strength shall not exceed 0.90.

9.3.6 Yield Strength Distribution

Upon completion of an order item exceeding 10 heats, all initial yield strength results (i.e., excluding any retest results) shall be fitted to a normal distribution curve. In the event that any such curve demonstrates an area underneath the curve below the specified minimum yield strength in excess of 2% of the total, the Manufacturer shall provide additional verification of compliance by a satisfactory explanation and handling of any low outliers, a demonstration of conservatism in the qualification results, or provisions for additional testing. Such verification is subject to review and acceptance by the Company.

9.3.7 Transverse Weld Tension Tests

For submerged-arc-welded pipe, transverse weld tension tests shall include determination of tensile strength and elongation for longitudinal and helical welds and shall meet the ultimate tensile strength requirements of Table 7 in API 5L for PSL 2 pipe.

9.8 CVN Impact Test for PSL 2 Pipe

9.8.2 Pipe Body tests

9.8.2.1

The minimum average (of a set of three test pieces) absorbed energy for each pipe body test shall be the greater of 40 J (30 ft-lb), the values stated in Table 8 in API 5L, and the values provided in the specification datasheet. The test temperature shall be the lesser of −5°C (23°F) and the temperature provided in the specification datasheet. A minimum all-heat average (average of all test units applied against an order item) may be required if indicated in the specification datasheet.

9.8.2.2

For welded pipe of all diameters, the minimum averages (set of three test pieces) shear fracture area for each test shall be at least 85%.

9.8.3 Pipe Weld and HAZ Tests

9.8.3.1

The minimum average (of a set of three test pieces) absorbed energy for each pipe weld and HAZ test shall be the greater of those cited in Clause 9.8.3 and the values provided in the specification datasheet. The test temperature shall be the lesser of −5°C (23°F) and the temperature provided in the specification datasheet.

9.9 DWT Test for PSL 2 Welded Pipe

9.9.1

The test temperature shall be the lesser of −5°C (23°F) and the CVN test temperature provided in the specification datasheet.

9.10 Surface Conditions, Imperfections, and Defects

9.10.4 Laminations

9.10.4.1

The accumulated length of indications transverse to the pipe axis shall not exceed 6.4 mm (0.250 in.) in any 50 mm (2 in.) of circumferential length.

9.10.5 Geometric Deviations

9.10.5.1

Other than dents, geometric deviations from the normal cylindrical contour of the pipe (e.g., flat spots and peaks) within 100 mm (4.0 in.) of the pipe ends that occur as a result of the pipe forming process or manufacturing operations and that exceed 2.0 mm (0.080 in.) in depth, measured as the gap between the extreme point of the deviation and the prolongation of the normal contour of the pipe, shall be considered defects and shall be treated in accordance with C.3 b) or C.3 c).

9.10.5.3

The following dents are not permissible and shall be treated in accordance with C.3b) or C.3c):

a) Dents with a depth greater than 4 mm (0.157 in.)

b) Dents encompassing all or part of a weld seam

c) Dents encroaching on an area within 300 mm (12 in.) of a pipe end

9.10.7 Other Surface Imperfections

a) Surface discontinuities (sharp notches, gouges, scores, scabs, slivers, etc.) and any other stress raising imperfections shall be treated in accordance with C.2, even though they may be less than the maximum depth permissible for imperfections.

b) After treatment in accordance with C.2, the minimum remaining wall thickness shall not be less than the minimum wall thickness per Clause 9.11.3.2 of this specification.

c) Shallow, isolated, non-stress rising imperfections such as round-bottom pits may be treated in accordance with C.1. Sharp-bottomed pits (including corrosion pits) or clusters of round bottom pits shall be treated in accordance with C.2, C.3b), or C.3c).

d) Heavy grinds visually encroaching on minimum wall thickness tolerance (per b) above) shall have the remaining wall thickness verified with a calibrated micrometer, straight probe UT device, or other means deemed acceptable by the Company.

9.11 Dimensions, Mass, and Tolerance

9.11.1 Dimensions

9.11.1.3

The pipe shall be delivered in lengths as specified in the specification datasheet.

9.11.3 Tolerance for Diameter, Wall Thickness, Length, and Straightness

9.11.3.1

The outside diameter tolerance of the pipe body shall be +0.50%, −0.15% of the nominal outside diameter for all D/t ratios anywhere along the pipe length.

The outside diameter tolerance of the pipe ends shall be the more restrictive of +0.50%, −0.15%, or ±1.6 mm (0.063 in.) and shall apply for a distance of 150 mm (5.9 in.) from the pipe ends.

For all pipe, the maximum difference between the measurements of the major and minor axes of the pipe ends shall not exceed the following values as a function of nominal pipe outer diameter.

Table 10.1 – Pipe End OOR Requirements

Nominal Pipe Outer Diameter (inches)	Maximum OOR (1/16 in.)
</= 28	3
29 – 37	4
38 – 45	5
>45	6

Diameter and out-of-roundness measurement (OOR) for product verification shall be performed after hydrotesting.

9.11.3.2

The tolerance for wall thickness shall be −8%, +10% of the specified nominal wall thickness or per Table 11, whichever is more restrictive.

9.11.3.4

The tolerances for straightness shall be as follows:

a) The total deviation from a straight line, over the entire pipe length, shall be ≤ 0.15% of the pipe length, as shown in Figure 1. Consistent results > 0.10% shall require a documented effort from the Manufacturer to improve straightness for the duration of the run.

b) The local deviation from a straight line in the 1,000 mm (36 in.) portion at each pipe end shall be ≤ 3.0 mm (0.118 in.), as shown in Figure 2. Consistent results > 2.0 mm (0.080 in.) shall require documented effort from the Manufacturer to improve straightness for the duration of the run.

   Straightness measurement for product verification shall be performed after hydrotesting.

9.11.3.5

Any methods utilized to rework pipe in order to correct dimensions shall be described in the MPS per B.3 b) vi). Any methods not so described in the MPS shall be subject to Company review and acceptance prior to pipe shipment.

9.12 Finish of Pipe Ends

9.12.5 Plain Ends

9.12.5.2

Plain end pipe shall be furnished with a bevel angle of 30° (+5° and −0°) and a root of 1/16 in., (+1/32 in. and −0) over 95% of the circumference. The root face tolerance on the remaining 5% of the circumference, in the vicinity of the weld, shall be ±1/32 in.

Bevels that do not meet the requirements shall be fully re-machined. Local grinding or filing on the bevels to meet dimensional requirements is not permitted. Minor burrs and sharp edges shall be removed without forming an internal taper.

9.13 Tolerance for the Weld Seam – SAW

9.13.2 Height of the Weld Bead – SAW

9.13.2.2 SAW Pipe

d) The maximum height of the internal and external weld bead shall be 3.5 mm (0.138 in.) for all wall thicknesses.

e) Both ends of submerged-arc-welded pipe shall have the outside weld reinforcement removed for a distance of 125 mm (5 in.) from the end of the pipe such that the outside weld bead does not extend above the outside surface of the pipe by more than 0.25 mm (0.010 in).

f) The OD weld shall exhibit a smooth transition in contour from the pipe to the weld crown. Weld caps should exhibit a width-to-height ratio of at least 5:1. The wetting angle should be maintained at more than 120° (refer to Figure 4 below).

Note:

a) The height of the weld bead shall not be below the prolongation of the surface of the pipe (outside or inside).

b) The Manufacturer shall have the option of grinding or machining the weld bead to the specified height.

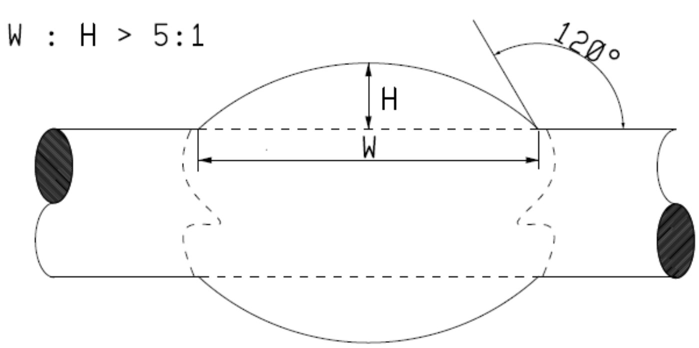


Figure 4 – Dimensional deviations of the weld seam

9.16 Hardness

The hardness in the weld, heat-affected zone, and base metal shall not exceed 300 HV_{500} when tested as specified by ASTM E384.

10 Inspection

10.2 Specific Inspection

10.2.1 Inspection Frequency

10.2.1.2

For PSL 2 pipe, the inspection frequency shall be as stipulated by Table 18 with the following additions:

a) DWT testing shall be required at a frequency of once per test unit of pipe with the same cold-expansion ratio.

b) Metallographic and microhardness traverse testing of the longitudinal or helical seam (in accordance with Clause 8.6.4) shall be conducted at a frequency as follows:

   i. At least once per operating shift per weld procedure (if multiple welding stands are utilized, test coupons shall alternate amongst them)

   ii. Whenever changes to grade, specified OD, or specified WT are made

   iii. Whenever significant excursions from operating conditions are encountered

   iv. Not less than once for each test unit supplied

c) A tensile test oriented longitudinally to the pipe axis (per Figure 5 c), Coupon #2) shall be tested for information only from 5% of test units supplied (minimum of one per order item to a maximum of 10).

d) A DWT and CVN temperature/toughness transition curve from 5% of test units shall be supplied (minimum of one per order item to a maximum of 10) for all orders.

e) Pipe end diameter and out-of-roundness shall be measured on each field end of every pipe.

f) The pipe body outside diameter shall be measured in three additional locations equidistant along the pipe length at a minimum frequency of one pipe per test unit.

g) Straightness (per Clause 9.11.3.4) shall be checked and reported at a minimum frequency of once per four-hour operating shift.

h) End squareness (per Clause 9.12.1.4) shall be checked and reported at a minimum frequency of once per four-hour operating shift.

10.2.3 Samples and Test Pieces for Mechanical Tests

10.2.3.2 Test Pieces for the Tensile Test

10.2.3.2.1

The use of methods other than full wall thickness flattened rectangular test pieces for verification of Clause 9.3 requirements shall require prior approval from the Company. The Manufacturer shall have a written procedure for flattening test coupons in a consistent manner.

10.2.5 Macrographic and Metallographic Tests

10.2.5.5

The hardness in the weld, heat-affected zone, and base metal shall not exceed 300 HV_{500}, as determined using test methods in accordance with ASTM E384. The traverse pattern shall conform to the one described in Clause 8.6.4.

10.2.6 Hydrostatic Test

10.2.6.7

The nominal wall thickness shall be used for the determination of the required test pressure.

10.2.6.8

Each pipe shall withstand, without leakage, a mill hydrostatic test to at least the pressure necessary to stress the pipe wall to 95% of the specified minimum yield strength (SMYS), based upon the specified outside diameter and nominal wall thickness. This hydrostatic test pressure shall be calculated based on the equation in API 5L 10.2.6.5 (Barlow's equation) without consideration of end loading. Test pressure shall be held constant for not less than 10 sec.

10.2.6.9

The Manufacturer shall immediately determine the cause of any hydrostatic test leak or burst and shall provide a written report to the Company along with any corrective/preventative actions to be implemented.

10.2.6.10

Individual pressure chart recordings shall be traceable to each pipe number and heat number. Hydrostatic test pressure gauges shall be calibrated with a deadweight tester prior to commencement of production, after each expander failure and hydrostatic test failure, and at least weekly thereafter. Testing shall be performed in the presence of the Company. If a regularly scheduled deadweight check reveals a non-conservative discrepancy, all pipe tested between the failing result and the previous successful result shall be retested.

10.2.6.11

The Manufacturer shall provide the formal test reports, complete with pressure charts, to the Company.

10.2.7 Visual Inspection

10.2.7.5

The inside and outside surfaces of pipe presented for inspection shall be clean and free of unacceptable metallic or non-metallic contaminants, including oil, grease, dirt, excessive rust scale, grinding residue, and welding flux. If the Company determines that pipe has an unacceptable level of cleanliness, it shall be returned to the Manufacturer for cleaning by methods acceptable to the Company. Heat and pipe number identification shall be maintained.

10.2.7.6

Visual inspection shall include the following:

a) The Manufacturer's Inspector shall walk the full length of the pipe to examine the entire external pipe surface including the weld seam.

b) The Manufacturer's Inspector shall crawl the full length of the pipe to examine the internal pipe surface end to end. For pipe that is 508 mm (20 in.) OD and smaller, the pipe internal inspection may be carried out visually at each end using suitable inspection lamps.

c) The Manufacturer's Inspector shall examine the finished pipe ends.

10.2.13 Equipment Calibration

All adjustable measuring devices for all inspection and testing shall be checked with standards traceable to NIST or equivalent. Mechanical testing machines shall be calibrated as specified by ASTM E4. Impact testing equipment shall be calibrated as specified by ASTM E23. Non-adjustable measuring devices such as rulers, squares, protractors, and tape measures shall be verified for good working conditions at a minimum of once per shift.

11 Marking

11.1 General

11.1.3

Additional marking requirements, if required, shall be outlined in the specification datasheet.

11.1.4

The pipe Manufacturer shall assign a unique traceability number to each length of pipe to facilitate tracking through production and finishing and shall ensure that each section of pipe and jointer pipe are identifiable during each stage of the manufacturing process.

11.2 Pipe Markings

11.2.1 j)

Each jointer pipe shall also be identified with this specification's number

11.2.2 c) 3)

The pipe number, length, and heat number (or code traceable to the heat number) shall be legibly stencilled on the inside of both ends of each pipe.

11.2.7.1

Colour coding requirements shall be specified in the specification datasheet, if required.

13 Retention of Records

13.1 Mill Test Reports

The Manufacturer shall, within two weeks of manufacturing completion of each order, supply mill test reports in PDF format as well as the source test data in an excel spreadsheet. Supply of material test certificates shall be a condition of acceptance and payment for pipe.

13.2 Heat-to-Pipe Traceability

The Manufacturer shall provide the Company with a correlation of pipe numbers to coil/plate numbers and heat numbers.

14 Pipe Loading and Shipping

14.1 Procedure Requirements

As part of the MPS package per B.3 c) x), the Manufacturer shall submit procedures that detail methods of protecting and securing pipe for mill shipment. Procedures shall indicate the location of bunks, bearing strips, spacers, and tie-down straps.

14.2 Minimum Standards

As a minimum, rail transportation shall be as specified by API RP 5L1 and marine transportation shall be specified by API RP 5LW. Rail transportation in North America shall additionally comply with all relevant AAR requirements.

14.3 Handling

Pipe shall be handled, stored, loaded, and transported in such a manner as to avoid damage, corrosion, and induction of additional residual magnetism. Nylon slings, padded forks, or special end hooks with soft non-metallic inserts shall be used for handling. The occurrence of critical stresses and the possibility of excessive cold work or fatigue cracking of the pipe in transit shall be avoided.

14.4 Weld Seam Protection

Weld seams of submerged-arc-welded pipe, including jointer welds, shall not contact separator blocks or any part of a truck, rail car, ship, or other transportation device.

14.5 Separation

No direct contact shall be permitted between adjacent pipe, pipe and metallic tie-down devices, or pipe and bulkheads. Minimum separation between pipe and bulkheads shall be at least 305 mm (1 ft.). Suitable non-metallic materials such as rope encirclements shall be used to prevent metal-to-metal contact.

14.6 Vesels

Rail cars, truck trailers, ship holds, and any other transportation devices shall be adequately cleaned before loading for shipment.

15 Reporting

The Manufacturer shall perform the following functions once an order has been placed.

15.1 Pipe Production Schedule

Prior to the commencement of an order, the Manufacturer shall list the start and finish dates for each diameter/wall thickness combination for the following stages of production:

a) Steelmaking
b) Plate/skelp production
c) Pipe production
d) Internal coating
e) External coating
f) Shipping from coating location
g) Arrival at destination

15.2 Daily Progress Report

Upon commencement of pipe making, the Manufacturer shall communicate to the Company scheduled and actual accumulated totals information for each diameter/wall thickness combination:

a) Finished pipe (total length produced and the number of discrete lengths produced)
b) Internally coated pipe
c) Externally coated pipe
d) Shipped pipe

15.3 Post-Production Review

During completion of the order, the Manufacturer shall provide the Company with the following information for every diameter/wall thickness combination produced.

a) A listing of all heats cast for the order, complete with chemical analysis and mechanical properties, as required by this specification

b) A listing of all pipe (pipe number and heat number) supplied for the order, complete with chemical analysis and mechanical properties as required by this specification

c) Certificates to be provided every three weeks following commencement of pipe manufacture

15.4 Electronic Reporting

15.4.1 Shipping Reports

The Manufacturer shall report pipe shipments on the shipping day by email to the Company as a spreadsheet or other format acceptable to the Company.

16 Company On-site Inspection

The Company's quality assurance personnel may be assigned to monitor all aspects of pipe production, testing, and shipping and to act as the Company's representative in all matters pertaining to inspection and acceptance of pipe. The Company's quality assurance personnel may also be assigned to monitor steelmaking, casting, and rolling operations.

The Company's pipe inspection representatives or third-parties designated by the Company shall have the authority to reject any pipe that does not comply with this specification.

The Manufacturer shall provide the Company with a current manufacturing and testing schedule (or equivalent) at least one week in advance of the start of any such activities to permit mobilization of the Company's representatives.

17 Right of Rejection

The Company reserves the right to reject all pipe supplied from a coil or test unit when more than 50% of the pipe from the coil or test unit does not conform to the prime intended product due to an accumulation of workmanship defects, mechanical test failures, nondestructive inspection rejects, or other deficiencies. Where less than 50% of the pipe length formed from any heat or coil complies with all other requirements of this specification, the Manufacturer shall advise the Company of such occurrences and shall obtain the Company's written decision.

18 Non Conformance Reports

18.1 Scope

At the discretion of the Company, a documented non-conformance report may be required from the Manufacturer in the following circumstances:

a) Product has passed final inspection and is subsequently found to be non-compliant with the requirements of API 5L and/or this specification

b) A systematic deficiency or failure of the Manufacturer's QMS is identified by the Company during production

c) Excessive reject rates in the pipe mill threaten scheduled deliveries and/or give the Company reason to suspect the quality of the remaining pipe

In such instances, the Company shall provide the Manufacturer with a written description of the non-conformance.

18.2 Investigation

A non-conformance report shall be formally submitted to the Company without undue delay. All non-conformance reports from the Manufacturer shall include the following elements:

a) Identification of the proximate and root causes of the non-conformance

b) A description of the action(s) taken to address the non-conforming joints (recall, rework, re-inspection, etc.)

c) Identification of the extent of the non-conformance (e.g., what joints were affected)

d) A description of preventative actions taken to prevent reoccurrence

Non-conformance reports are subject to review and acceptance by the Company.

19 Revision History

19.1 Revision 2.0, November 29, 2013

Incorporated TSCRs: 175-2012, 132-2011, 297-2007

Pending TSCR (to be reviewed next revision): 314-2013

Update better reflects industry capabilities and best practices. Document philosophy is based on API 5L as the basis with the addition of Enbridge supplementary requirements. Annex R was added to list the requirements to procure stock pipe.

Annex A
Specification for Welded Jointers

A.1 Method

A.1.1

Welding shall be performed using a process or combination of processes approved by the Company.

A.1.2

Welding procedures, welders, and welding machine operators shall be qualified in accordance with ASME/BPVC SEC IX or API STD 1104. Where ASME/BPVC SEC IX welds are utilized, Clauses 8.6.2 and 8.6.3 of this specification shall apply.

A.1.3

Copies of the welding procedure specification and procedure qualification record shall be provided with the manufacturing procedure specification.

A.1.4

Jointers may not be transported between passes without clamps unless a weldment greater than or equal to ½ nominal wall thickness has been achieved.

A.2 Workmanship

A.2.6

The maximum allowable offset between the outside surfaces of adjoining lengths of pipe shall be 2.5 mm (0.098 in.).

A.3 Marking

A.3.1

Each jointer shall be identified with a unique number that is fully traceable through the Manufacturer's quality system to the coils, plates, slabs, ingots, strands, ladles, or heats used to make each pipe of the finished jointer pipe.

A.3.2

Welding records shall be fully traceable to jointer welds produced and provided to the Company in an approved format.

A.4 Nondestructive Inspection

Circumferential jointer welds shall be inspected for longitudinal and transverse imperfections by radiological methods, ultrasonic methods, or both in accordance with Annex E, except that fluoroscopic inspection shall not be accepted for specification compliance. The junctions of circumferential jointer welds and other submerged-arc welds shall be inspected by film radiography or non-film radiography imaging techniques.

A.5 Mechanical Tests

A.5.1 Transverse Weld Tensile Test – Jointer Welds

For circumferential mill jointer welds, tests shall be conducted at a frequency of one test per lot of 100 welds and shall meet the ultimate tensile strength requirements of this specification for the applicable grade of pipe.

A.5.2 Guided Bend Tests – Jointer Welds

For circumferential mill jointer welds, face and root guided-bend tests shall be conducted at a frequency of one test per lot of 100 welds.

A.5.3 Hardness Testing – Jointer Welds

Microhardness traverse testing (per Clause 8.6.4) of mill jointers shall be tested at a frequency of one test per lot of 100 welds and shall meet the requirements of Clause 9.16.

A.5.4 Charpy Impact Testing

If demonstrated impact toughness in the circumferential welds is required by the specification datasheet, tests shall be conducted as part of the weld procedure qualification and at a frequency of one test per lot of 100 welds. Testing shall conform to the requirements of Clause 9.8.2.

A.6 Repair Welds to Jointer Welds

Repair welds to the SAW weld seams are permissible in accordance with the requirements of Annex C and D of API 5L and this specification.

Annex B
Manufacturing Procedure Qualification for Pipe

B.3 Characteristics of the Manufacturing Procedure

Note: This clause has been extensively expanded in Annex N of Addendum 3 (Jan 1, 2012). All provisions of the latest Addendum shall be incorporated in the Manufacturer MPS where applicable to the process.

B.3.1 Additional Characteristics of the Manufacturing Procedure

The MPS submitted shall include the following detailed information:

i) A description of laboratory test equipment present at the manufacturing plant or third-party companies contracted for final qualification testing of material properties for the order

ii) A description of the inspection facilities available to onsite Company representatives

iii) A written practice for the training and certification of NDT personnel in compliance with ASNT-SNT-TC-1A or ISO 11484 requirements

iv) Processes and practices for ensuring internal slab quality (including centreline segregation) per Clause 8.3.10

v) A description of welding flux hydrogen mitigation per Clause 8.6.6

vi) Method and typical amount of cold expansion, as applicable

vii) Documentation per Clause 14.1

viii) Copies of up-to-date QMS certification demonstrating compliance to Clause 2.3

ix) An inspection and test plan per B.4

x) Documentation relating to NDT per Clause E.2.1 of this specification

xi) Documentation per Clause 9.3.3

B.3.2 Order Specific MPS Items per Clause 8.1.1

B.3 a) iii)

B.3 c) iii) and iv)

B.3 e) iii)

If the Manufacturer wishes to qualify a new WPS or extend the qualification range of the submitted WPS with a new PQR on commencement of or during production, it may be done, provided that it utilizes the same welding process or combination of processes and notification and submission of the qualified procedure to the Company.

B.3.1 x)

Any deviations from the MPS submitted with the quotation that are subsequently deemed necessary, with explanation.

B.4 Characteristics of the Inspection and Test Plan

Note: This clause has been added to Annex N of Addendum 3 (Jan 1, 2012). All provisions of the latest Addendum shall be incorporated in the inspection and test plan.

B.4.1

The inspection and test plan shall reference all internal operating procedures governing verification at each station. The Company may request to review any of these referenced procedures.

Annex C
Treatment of Surface Imperfections and Defects

C.4 Repair of Defects by Welding

C.4.1

Repair of pipe body is not permitted, regardless of product specification level.

C.4.9

The depth of the ground and cleaned cavity prior to welding shall not exceed two-thirds of the specified wall thickness.

C.5.10

The minimum length of repair shall be 50 mm (2.0 in.).

C.5.11

Back-to-back repairs by welding are not permitted.

C.5.12

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

C.5.13

The maximum length of any repair shall be 250 mm (10 in.).

C.5.14

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

C.5.15

There shall not be more than two repairs in any 6 m (20 ft.) of weld.

Annex D
Repair Welding Procedure

D.2 Repair Welding Procedure Qualification

D.2.3 Mechanical Testing

D.2.3.4 Charpy (CVN) Impact Testing

D.2.3.4.4

The test temperature and minimum energy absorbed requirements shall match those of the associated SAW seam weld (refer to Clause 9.8.3).

D.2.3.5. Hardness Test

Hardness tests shall be performed In accordance with Clause 8.6.4 and shall comply with the requirements of Clause 8.6.4.

Annex E
Nondestructive Inspection for Other than Sour Service or Offshore Service

E.2 Standard Practices for Inspection

E.2.1

The Manufacturer shall submit detailed written procedures for all nondestructive examination methods, including visual examination, for acceptance by the Company prior to the start of a specific order production. Written procedures shall include a description of reference standards, calibration methods, sensitivity assessment, physical arrangement of test equipment, alignment of test equipment with test item, methods of accurately locating and assessing imperfections, acceptance criteria, technical qualification requirements, and recording and reporting requirements for both dynamic and static modes of inspection, as applicable.

E.3 Methods of Inspection

E.3.1 General

E.3.1.2.1

a) Longitudinal and helical weld seams shall be inspected for internal and external longitudinal and transverse imperfections by ultrasonic methods as specified by this specification.

b) Repair welds shall be inspected by radiological methods. Fluoroscopic inspection shall not be accepted for specification compliance.

c) Circumferential jointer welds produced by double-submerged-arc welding shall be inspected for longitudinal and transverse imperfections by radiological methods, by ultrasonic methods, or by a combination of radiological and ultrasonic methods. Fluoroscopic inspection shall not be accepted for specification compliance.

d) The junctions of jointer welds and other submerged-arc welds shall be inspected by radiological imaging techniques or by ultrasonic inspection methods. Fluoroscopic inspection shall not be accepted for specification compliance.

E.3.1.3

The location of equipment in the Manufacturer's facility shall be such that all final UT and pipe end RT inspection of the SAWL or SAWH seam shall be performed after final hydrostatic testing.

E.3.2 Pipe End Inspection – Welded Pipe

E 3.2.3

Ultrasonic inspection in accordance with the method described in ASTM A578 and ASTM A435 or ISO 10893 shall be used to verify that the 25 mm (1.0 in.) wide zone at each pipe end is free of laminar imperfections > 6.4 mm (0.25 in.) in the circumferential direction.

E.4 Radiographic Inspection of Weld Seams

E.4.2 Radiographic Inspection Equipment

E.4.2.4

Unexposed base density of film shall not exceed 0.30 and, as a minimum, shall be measured and recorded for each new roll or box of film.

E.4.2.5

Film density determinations shall be made using a photoelectric densitometer.

E.4.2.6

Radiographs and their reports shall together be clearly and permanently identified and traceable with respect to pipe number, pipe position, date of examination, examination results, repair location (if applicable), Company name, inspection company name, project name, and technician name.

E.5 Ultrasonic Inspection

E.5.2 Ultrasonic Inspection Reference Standards

E.5.2.6

Reference standards shall contain machined calibration reflectors as follows:

a) 1.6 mm (1/16 in.) radially drilled hole, for application of acceptance limits and for setting of alarm levels applicable to longitudinal and transverse defect inspection

b) Rectangular notches, ID and OD, longitudinal orientation (dimensional tolerances as specified in Table E.7 of API 5L) for the verification that the sound beam for longitudinal defect inspection is being directed perpendicular to the weld line. Notches may also be employed for transverse weld inspection calibration.

E.5.5 Acceptance Limits

E.5.5.5

For all nondestructive inspection applied for specification and production control purposes, any paint markings applied to the pipe to mark locations where alarm limits were exceeded or where imperfections were noted shall be removed, painted over with black paint, or physically marked as having been resolved in the event that additional (prove-up) inspection or rework subsequently deems them to be compliant with API 5L and this specification.

E.7 Residual Magnetism

E.7.3.1

A calibrated Hall Effect gaussmeter that produces accurate and consistent results is required. The meter shall be calibrated at required intervals and the Manufacturer's operating instruction followed. Maximum readings occur when the flux lines are perpendicular to the sensor (Hall Element).

E.7.4

Measurements shall be made on each end of at least three pipes at four-hour intervals during the operating shift. The measurements shall be recorded and documented.

E.7.5.1

Residual magnetism shall be measured on both ends of all pipes following any inspection or process that utilizes or produces a magnetic field prior to loading for shipment from the Manufacturer's facility.

E.7.6.1

The hall element area of the probe shall be in contact with the root face or square-cut face when the reading is taken. The flux lines shall be perpendicular to the hall element of the probe to ensure that maximum readings are obtained.

E.7.11

Measurements made on pipe in stacks or bundles are not considered valid. Pipes shall be separated by at least 300 mm (12 in) and shall not be in contact in order to achieve valid residual magnetism readings. Pipe shall not be in contact with the ground and shall be off the ground at least 150 mm (6 in.) in height.

E.8 Laminar Imperfections in the Pipe Body

The requirement of API 5L Clause E.8 shall be mandatory. Coverage shall represent ≥ 35% of the pipe body surface inspected.

E.9 Laminar Imperfections along the Strip/Plate Edges

The requirement of API 5L Clause E.9 shall be mandatory. If the Manufacturer elects to perform this inspection after seam welding, the straight probe shall be as close as practicable to the weld seam.

Annex Q
Specification Datasheet

Specification Datasheet
(to be completed by Company representative)

PROJECT:
PURCHASING COMPANY:
UNITS OF MEASUREMENT (See Clause 2.1): ☐ SI ☐ USC

Pipe Requirements

Item No.	Outside Diameter (OD) (in./mm)	Wall Thickness (WT) (in./mm)	Grade	Quantity (ft./m)	Production Specification Level (PSL)
					PSL 2

Design, Operating, and Construction Information

Project Location	☐ Canada ☐ US	Pipe Required to Meet Annex R Requirements Only?	☐ Yes ☐ No

Class Location	Service / Application Type	Maximum Operating Pressure (psi/kPa)	Maximum Operating Temperature (°F/°C)	Minimum Operating Temperature (°F/°C)

Construction	Engineering Critical Assessment Required?	☐ Yes ☐ No	Jointers Permitted?	☐ Yes ☐ No	Pipe Required for Induction Bending?	☐ Yes ☐ No

Notch Toughness Tests

	Test Location	Test Temp (°F/°C)	Minimum Energy (Joules)[1]	
			Single Test Unit	All-Heat Average
Charpy Impact Test (Energy Absorbed)	Pipe Body			
	Weld/HAZ (SAWL/SAWH)			
	Weld/HAZ (Jointer)			

Pipe Length

Min. Single Pipe Length (ft./m)	Max. Single Pipe Length (ft./m)	Min. Average Pipe Length (ft./m)

Pipe Coating

Coating Location	Coating Type	Coating Thickness

Pipe Coating Cutback Length (in./mm)[2]

ID	OD

Pipe Colour Code

Required	☐ Yes ☐ No	Colour	

Note 1: Energy requirements are for full-size specimens.
Note 2: The minimum cutback length requirement shall be in accordance with the NDT provider and automatic welding Vendor (if applicable).

Specification Datasheet

(to be completed by Company representative)

Other					
Revision	Description	Initiated By	Reviewed By	Approved By	Date

Annex R
Requirements for Stock Pipe Procurement

Annex R is to be used in conjunction with API 5L, forty-fourth edition for qualification, inspection, and testing of off-the-shelf steel line pipe for use in transportation of non-sour, onshore hydrocarbon fluids. Pipe shall be sourced from approved Vendors. A sample MTR shall be supplied as part of the tender documentation from the supplier. All requirements of Table R.1 shall be met.

Pipe purchased to Annex R requirements shall not contain mill jointers.

Table R.1 – Stock Pipe Requirements

Item	Test	Test Procedure/ Clause Reference	Frequency/Acceptance Criteria	Additional Requirements/Comments
1	Chemical composition	Clauses 9.2.4 and 9.2.5 of API 5L.	– The chemistry shall conform to API 5L requirements for SAW PSL 2 pipe. – The carbon equivalent shall not exceed CE_{Pcm}: 0.25.	By pipe MTR review
2	Tensile properties	Clause 9.3.2 and Table 7 of API 5L.	– The actual yield strengths based on laboratory qualification testing shall not exceed SMYS plus 19,000 psi (131 MPa) for each pipe order of a specific diameter, wall thickness, and grade – The ratio of yield strength to ultimate tensile strength shall not exceed 0.90.	By pipe MTR review
3	CVN impact test for PSL 2 pipe	Clause 9.8 of API 5L.	– Pipe body tests as specified in the specification datasheet at the specified test temperature – Pipe weld zone tests as specified in the specification datasheet at the specified test temperature	By pipe MTR review or by additional CVN impact testing per qualification lot
4	UT inspection of the SAWL/ SAWH seam	Annex E	A full length manual UT inspection of the SAWH or SAWL seam of one joint per every 50 per size/grade per Manufacturer (minimum of one per order item)	By inspection personnel qualified in accordance with E.1 of API 5L and this specification. Any rejectable indications per Annex E of API 5L shall be grounds for disqualification of all.
5	NDE of bevel face	Clause 9.10.4	All ends to be welded shall be inspected for the presence of laminar-type discontinuities using MPI or LPI.	By inspection personnel qualified in accordance with E.1 of API 5L and this specification
6	Visual inspection of pipe storage	Inspector walking the full pipe storage	All stacks: properly stockpiled, no direct contact between adjacent pipe, end caps in place, etc.	By inspection personnel qualified in accordance with Clause 10.2.7.3 of API 5L

Item	Test	Test Procedure/ Clause Reference	Frequency/Acceptance Criteria	Additional Requirements/Comments
7	Visual inspection of pipe surface – external	The entire external surface including the weld zone, by the Inspector walking the full length of the pipe	– Absence of dents, surface defects, hard spots – No slivers, scabs, undercuts bristles, pitting, or other surface imperfections that could result in an unacceptable shop/field coating application	By inspection personnel qualified in accordance with Clause 10.2.7.3 of API 5L
8	Visual inspection of pipe surface – internal	The internal surface, end to end, by crawling the pipe greater than 610 mm (24 in) OD For pipe 610 mm (24 in) OD and smaller, the pipe internal inspection may be carried out visually at each end using suitable inspection lamps.	– Absence of dents, surface defects, hard spots – Clean and free of unacceptable metallic or non-metallic contaminants, including oil, grease, dirt, excessive rust scale, grinding residue, and welding flux – No slivers, scabs, undercuts, bristles, pits, or other surface imperfections that could result in an unacceptable shop/field coating application or initiation sites for internal corrosion.	By inspection personnel qualified in accordance with Clause 10.2.7.3 of API 5L
9	Verification of dimensions and residual magnetism	– OD – Out-of-roundness – Wall thickness – Straightness – Magnetism	– All pipe shall be checked for compliance to API 5L requirements.	– By inspection personnel trained in the use of pertinent measuring equipment. – Measurement of magnetism shall be performed with a calibrated Hall Effect Gaussmeter on individual pipe removed from the stack.
10	Verification of pipe ends	– Out-of-squareness – Radial offset – Bevel/land dimensions	– All pipe shall be checked for compliance to API 5L requirements.	By inspection personnel trained in the use of pertinent measuring equipment
11	Pipe marking	Clause 11.2 of API 5L	All identification markings shall be clearly visible and legible (pipe number and heat number (or code traceable to the heat number) on each joint of pipe traceable by pipe MTR.	By trained inspection personnel
12	QA/QC and inspection documents	Clauses 2.3 and 10.1.3.1 of API 5L	– Copy of API Q1 and ISO 9001 quality certificates covering the date of pipe production	Review of documentation provided by mill or distributor
13	Pipe for use of factory-made induction bending	If specified in the specification datasheet	– Pipe shall be longitudinal seam SAW pipe (SAWL). – Pipe so indicated shall meet the applicable requirements of ASME B16.49 Table 2.	By pipe MTR review

STATE OF MICHIGAN

BEFORE THE MICHIGAN PUBLIC SERVICE COMMISSION

IN RE ENBRIDGE ENERGY, LIMITED PARTNERSHIP **Application for the Authority to Replace and Relocate the Segment of Line 5 Crossing the Straits of Mackinac into a Tunnel Beneath the Straits of Mackinac, if Approval is Required Pursuant to 1929 PA 16; MCL 483.1 *et seq.* and Rule 447 of the Michigan Public Service Commission's Rules of Practice and Procedure, R 792.10447, or the Grant of other Appropriate Relief**	)	**Case No. U-20763**

CERTIFICATE OF SERVICE

Angela R. Babbitt hereby certifies that on the 23rd day of December, 2020, she served the Supplemental Direct Testimony and Exhibits of Aaron Dennis on behalf of Enbridge Energy, Limited Partnership's ("Enbridge") and this Certificate of Service in the above docket on the persons identified on the attached service list by electronic mail.

Angela R. Babbitt

Angela R. Babbitt

Angela R. Babbitt
Digitally signed by Angela R. Babbitt
Date: 2020.12.23 15:11:51 -05'00'

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