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Line 5 Straits of Mackinac
Hydrostatic Pressure Test Plan

Project AFE	20007132		
Document Owner	Enbridge Energy, Limited Partnership		
Version	REV-1	Version Date	2/24/2017

TABLE OF CONTENTS

1. TERMS & DEFINITIONS

Company Test Engineer	Engineer on site during the hydrostatic test who is responsible for ensuring the hydrostatic test results are in compliance with all applicable Company specifications, industry standards and test plans and procedures.
Construction Related Equipment	Used as part of construction or operations and maintenance activities within a facility and on the right of way (e.g., cranes, backhoes, vacuum trucks, etc.).
Contaminants	Presence of minor and unwanted constituent air, soil, and water as a result of contact or pressure of a released fluid.
Contract Workers	Persons hired for extended periods of time working under the direct supervision of Company employees.
Environmental Inspector	Company Representative for the project to ensure compliance with all Company standards and specifications, permits, and required notifications.
General Contractor	A contractor who enters into a contract with the Company for the construction of the project and who takes full responsibility for its completion. The contractor may enter into subcontracts with others for the performance of specific parts or phases of the project.
Leak	Pipeline release that is less violent and sudden than a rupture, but has a more pronounced volume and flow than a seep.
Maximum Operating Pressure (MOP)	Pressure or pressure restrictions determined by the lowest value of the following pressure types: static hydrotest pressure data, flowing test pressure data, design pressure values based on pipe steel grade and wall thickness, or pressures or pressure restrictions imposed by a regulator. Determined by Enbridge's Operations and Maintenance Manual 01-02-02 Maximum Operating Pressure Algorithm for Mainline Piping.
Normal Operating Limit	Minimum and maximum set points that provide for the safe operation of the system and include suction pressure and discharge pressure set points.
Oil	Hydrocarbon or mixture of hydrocarbons other than gas or any substance designated as an oil product by regulations.
Operator Qualified (OQ)	Personnel qualification in the natural gas and liquid pipeline business in accordance with 49 CFR 192-Subpart N, 49 CFR 195-Subpart G and the Company US OQ Plan.
PLM/Operations	Enbridge Pipeline Maintenance (PLM) and Operations Personnel.

Release	Loss of containment of pipeline commodity including discharge, spray, spill, leak, seep and pour.
Rupture	Sudden loss of containment (release) event that involves immediate cessation of operations and/or involves extensive damage to pipeline and/or equipment.
Site Inspector	Company representative or appointed representative of the Company responsible for the inspection of the work (construction or maintenance activities).
Site Supervisor	Employee responsible for the location (e.g., PLM coordinator/supervisor, technician, terminal supervisor) or designate.
Specified Minimum Yield Strength (SMYS)	Minimum yield strength prescribed by the specification under which the material is purchased from the manufacturer.
Test Supervisor	Company representative who ensures the hydrostatic test is executed in accordance with all Company specifications and standards, test plans and project plans.
Waterbody	Area holding permanent or seasonal water, including but not limited to drainage channels, ditches, sloughs, wetlands, dugouts, ponds, creeks, streams, rovers or lakes.
Worker	Company employee, contract worker and contractor personnel.

1. PROJECT SUMMARY

The Line 5 Straits of Mackinac hydrostatic pressure test ("hydrotest") fulfills Enbridge's requirements under Paragraph 71.b of the proposed Consent Decree in *U.S. vs. Enbridge Energy, Limited Partnership, et. Al., (Civil Action No: 1:16-cv-914)*. The hydrotest will be performed to reduce or eliminate the potential that any axially-aligned Crack features in the Dual Pipelines could result in a leak or rupture of the dual pipelines that cross the Straits of Mackinac.

The scope of the hydrotest applies to the 4.09-mile portion of Line 5 consisting of two 20-inch diameter seamless pipelines that cross the Straits from the North Mackinac sending traps to the South Mackinaw station receiving traps. The test will be conducted in two phases. The first phase will test the west segment of the Mackinac crossing while the east segment will continue to operate. The second phase will test the east segment while the west segment will continue to operate. The hydrostatic testing sequence may be reversed at the discretion of the Company.

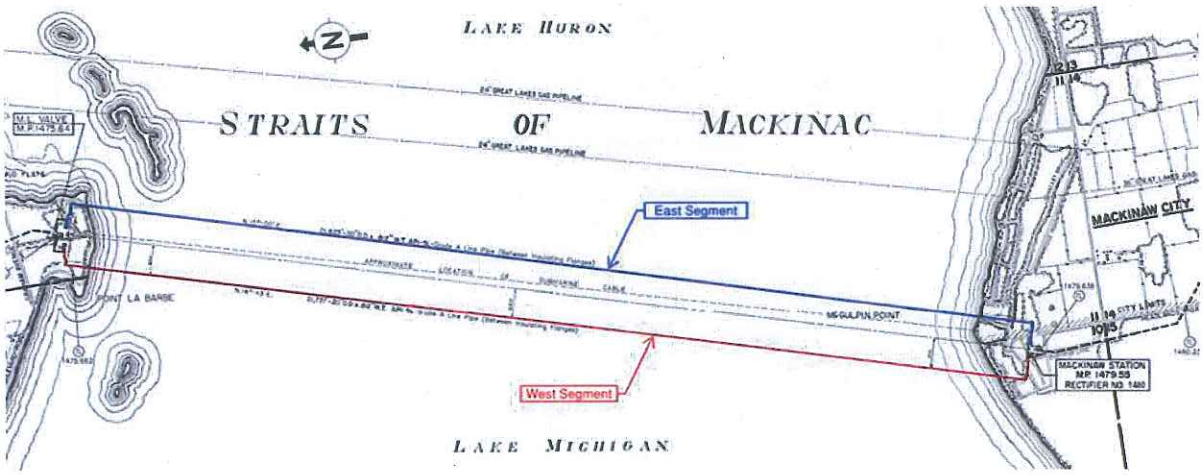
2. TEST PROCEDURE

2.1. GENERAL

This procedure identifies the details of testing each segment of the Line 5 Mackinac Crossing.

2.2. TEST SEGMENTS

The Line 5 Mackinac Crossing will be tested in two phases, the 4.09-mile west segment and the 4.09-mile east segment.



2.3. PIPING TO BE TESTED

Diameter	Wall Thickness	Grade	SMYS	West Length	East Length
Mainline Piping					
20"	0.812"	A	30,000 psi	21,706 ft	21,617 ft
Facility Piping					
2"	0.218"	A333-6	35,000 psi	23 ft	23 ft
24"	0.625"	X52	52, 000 psi	N/A	22 ft
20"	0.500"	X52	52,000 psi	292 ft	422 ft
20"	0.500"	X60	60,000 psi	130 ft	117 ft
24"	0.500"	X52	52,000 psi	22 ft	N/A
24"	0.500"	X60	60,000 psi	22 ft	22 ft

Table 1 Piping To Be Tested

2.4. TEST PRESSURE AND DURATION

Test pressures will meet or exceed the requirements in Paragraph 25.b. of the Consent Decree. Each segment will be strength tested to a minimum 2xMOP for four (4) hours followed by a leak test at a minimum of 1.1xMOP for four (4) hours. The test shall be performed over a continuous eight (8) hour period. A range of 20 psi will be used for the strength and leak test to allow for fluctuation in the test pressure due to temperature stabilization. In the event that water is added to adjust test pressures to compensate for temperature changes, the eight (8) hour portion of the test will be reinitiated. Test pressures for both segments are listed below.

Test	MOP	Range	Start of Segment	High Point Pressure	Low Point Pressure	End of Segment	Duration
Strength	600 PSIG	Min Pressure	1229 psig	1200 psig	1339 psig	1200 psig	4 Hours
		Max Pressure	1249 psig	1220 psig	1359 psig	1220 psig	
Leak	600 PSIG	Min Pressure	689 psig	660 psig	799 psig	660 psig	4 Hours
		Max Pressure	709 psig	680 psig	819 psig	680 psig	

Table 2 Test Pressure and Duration

2.5. TEST SEQUENCE

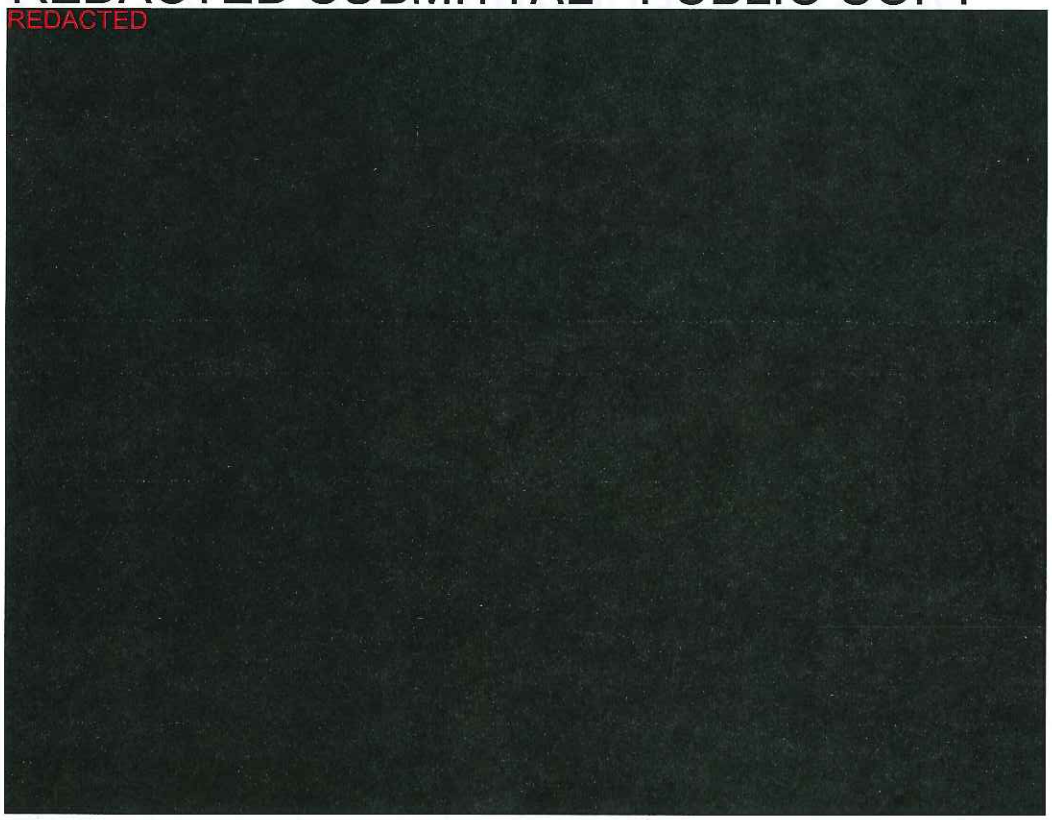
The west segment will be tested first and then returned to service followed by testing of the east segment.

2.6. TEST ISOLATION

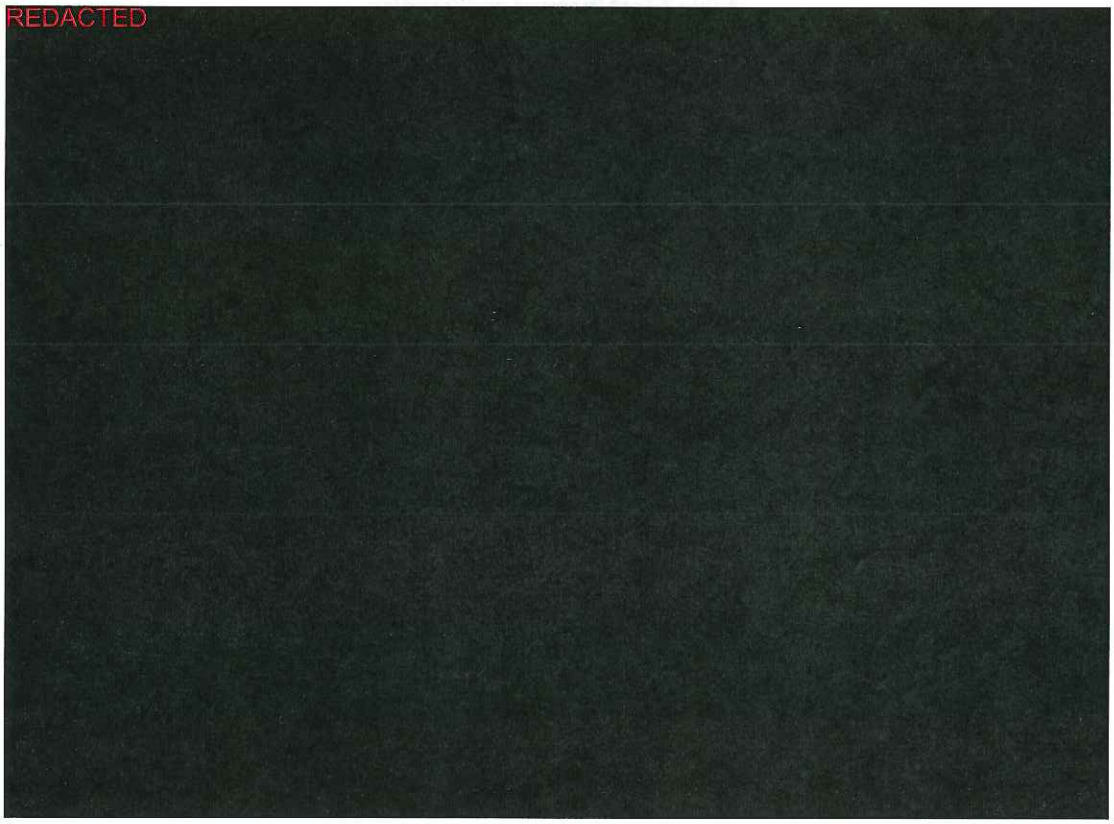
During testing, any valves that are included in the test will be set to the partially closed position.

2.6.1. WEST SEGMENT

The west segment will be isolated on the north end by removing valve 5.2-V-1 and installing blind flanges. The west segment will be isolated on the south end by removing valve 5.2-CV-1 and installing blind flanges. The existing configuration of associated piping on the west segment and the changes that will be made to facilitate the test are identified in the diagrams that follow.



West Straits Segment – Upstream Normal Operation (E1475.68-5.2-ST-2 & 5.2-V-1)



West Straits Segment – Upstream Hydrotest Isolation (E1475.68-5.2-ST-2 & 5.2-V-1)

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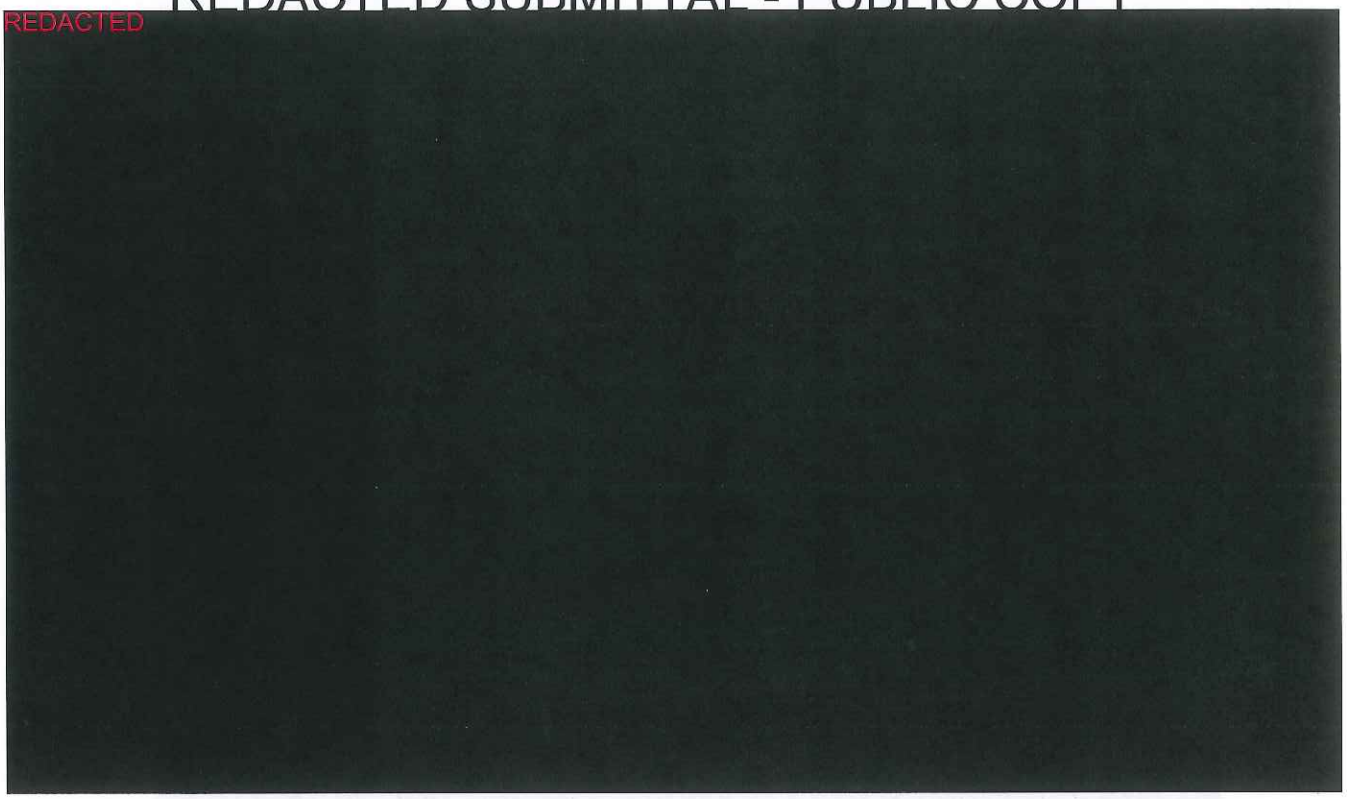

West Straits Segment – Downstream Normal Operation (E1479.55-5.2-ST-1 & 5.2-CV-1)

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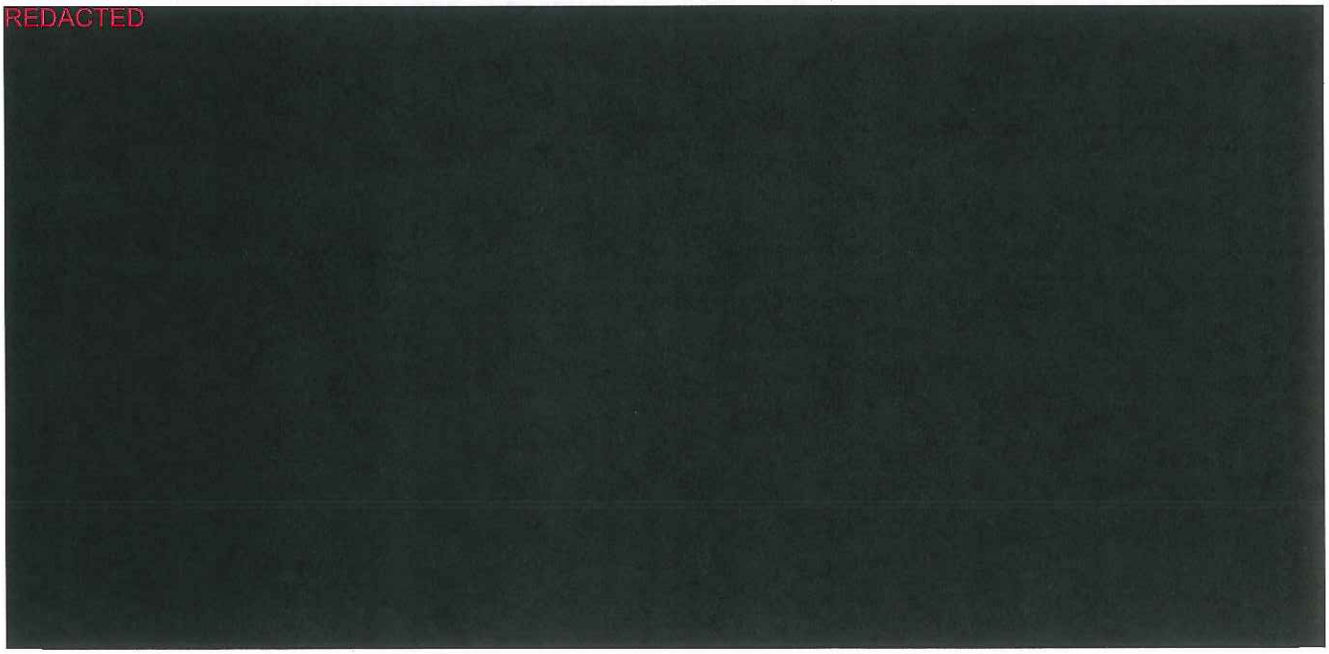
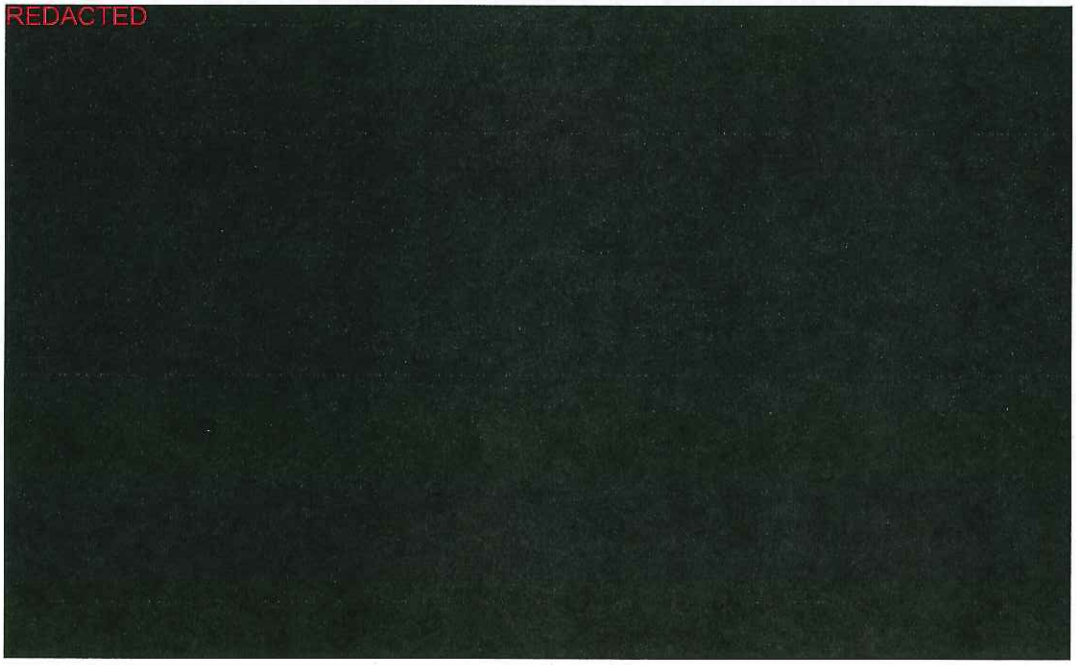


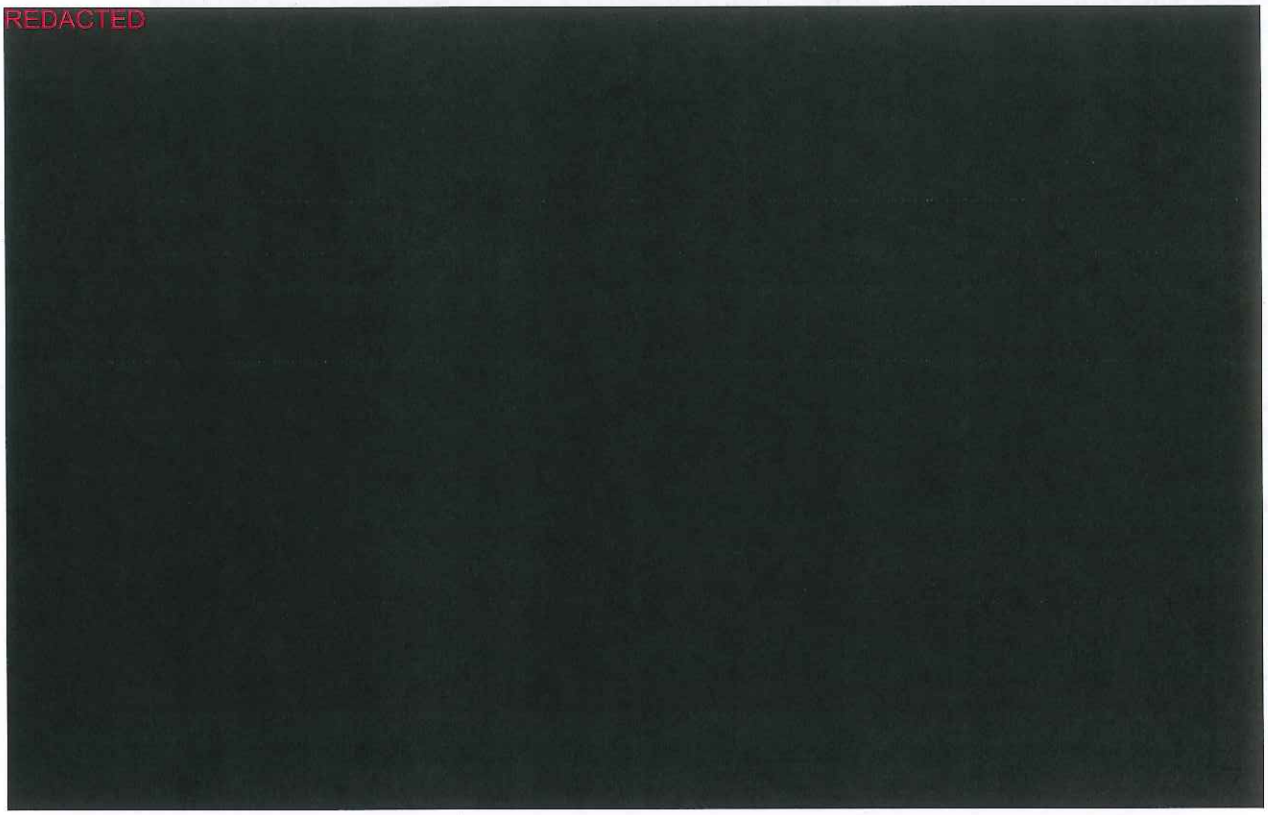
West Straits Segment – Downstream Hydrotest Isolation (E1479.55-5.2-ST-1 & 5.2-CV-1)

2.6.2. EAST SEGMENT

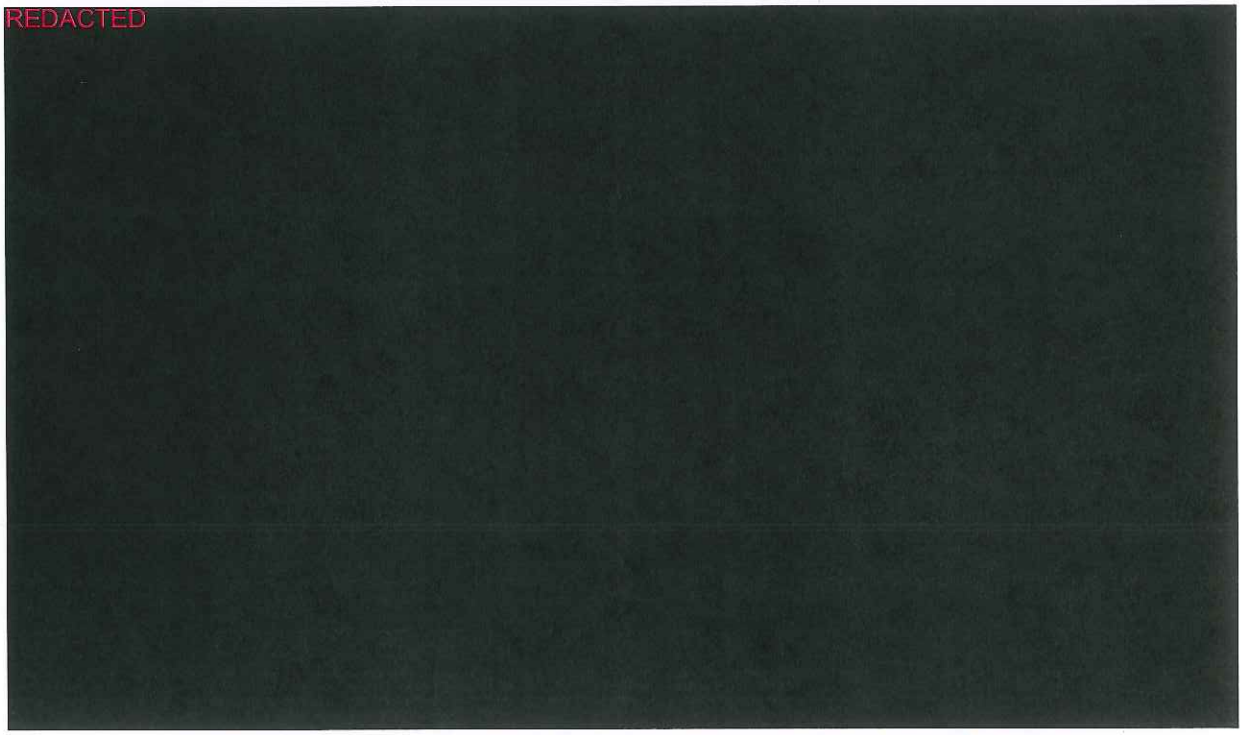
The east segment will be isolated on the north end by removing valve 5.1-V-1 and installing blind flanges. The east segment will be isolated on the south end by removing valve 5.1-CV-1 and installing blind flanges. The existing configuration of associated piping on the east segment and the changes that will be made to facilitate the test are identified in the diagrams that follow.



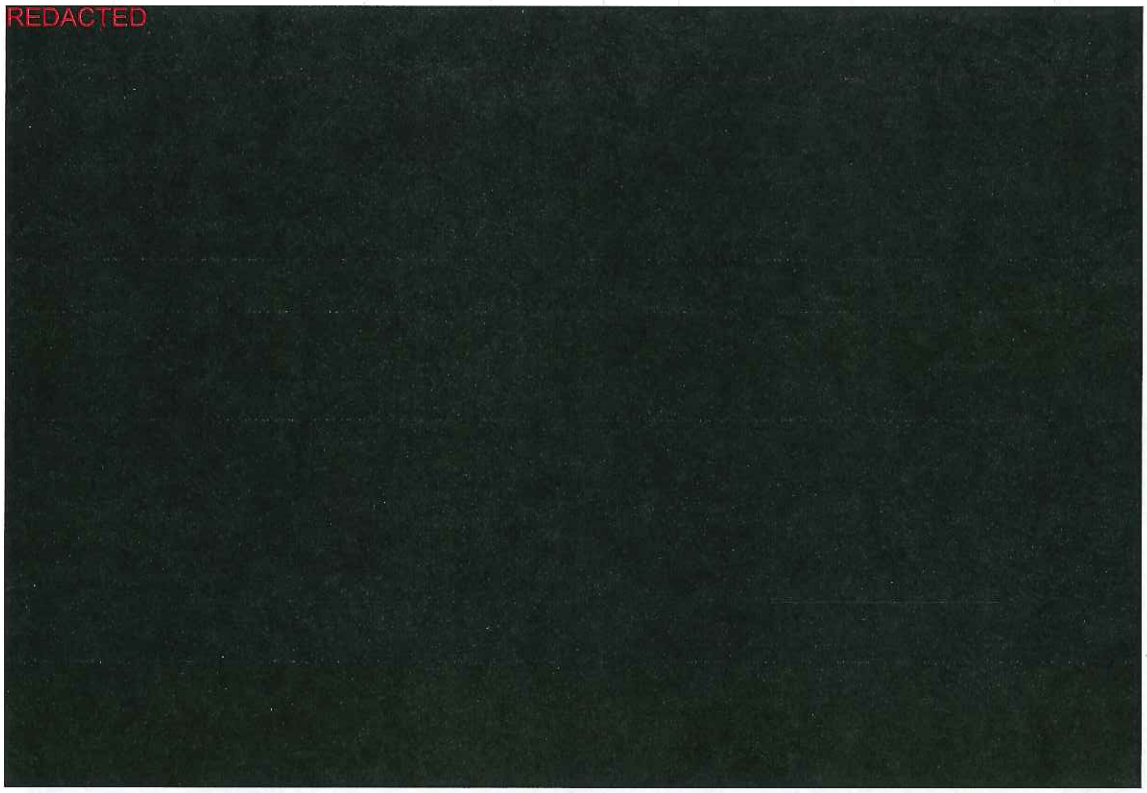
East Straits Segment – Upstream Normal Operation (E1475.68-5.1-ST-2 &5.1-V-1)



East Straits Segment – Upstream Hydrotest Isolation (E1475.68-5.1-ST-2 &5.1-V-1)

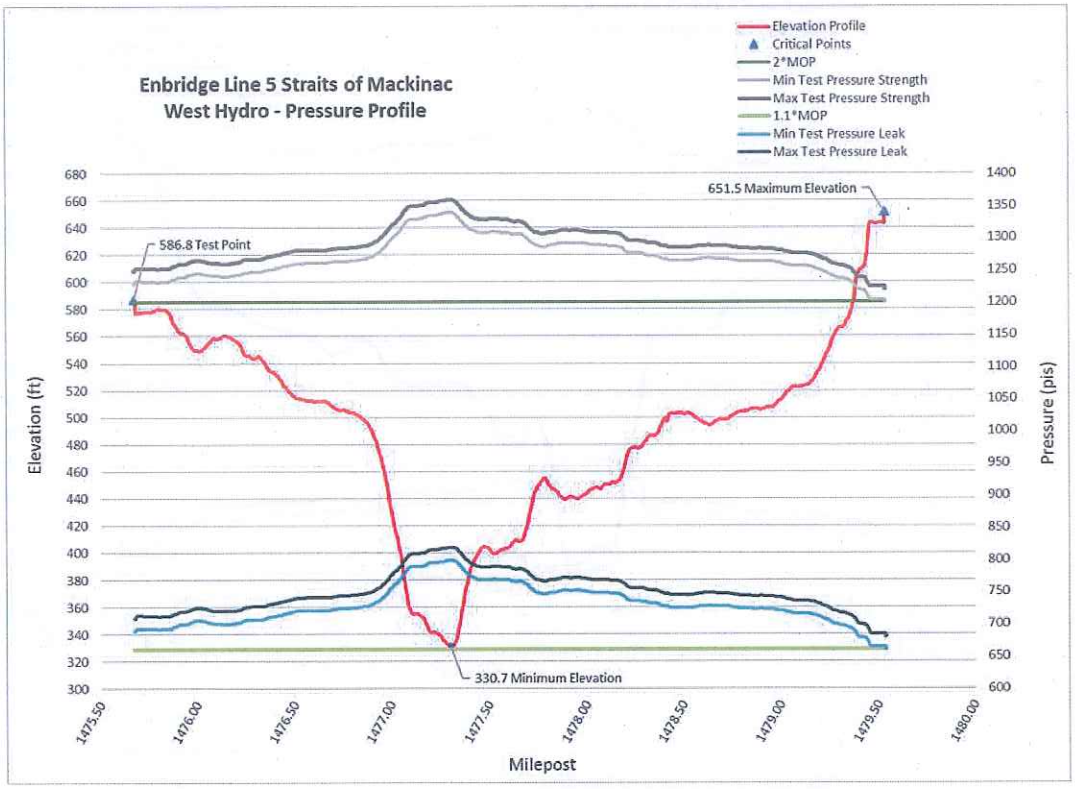


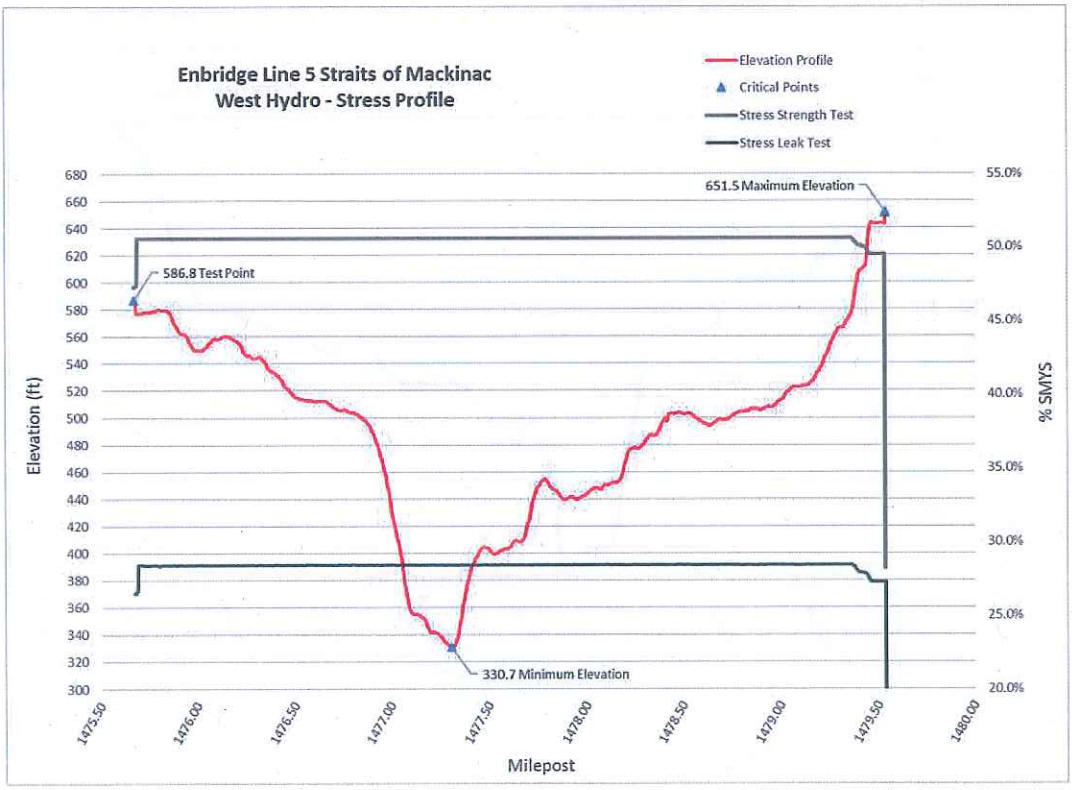
East Straits Segment – Downstream Normal Operation (E1479.55-5.1-ST-1 & 5.1-CV-1)

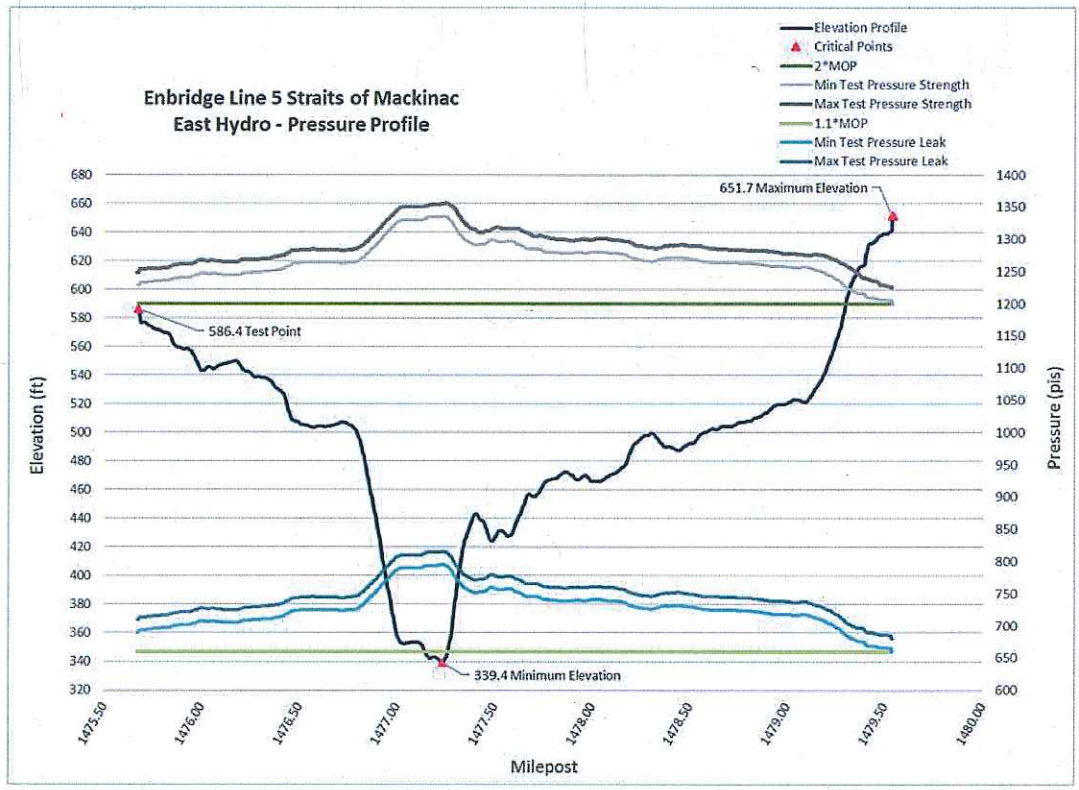


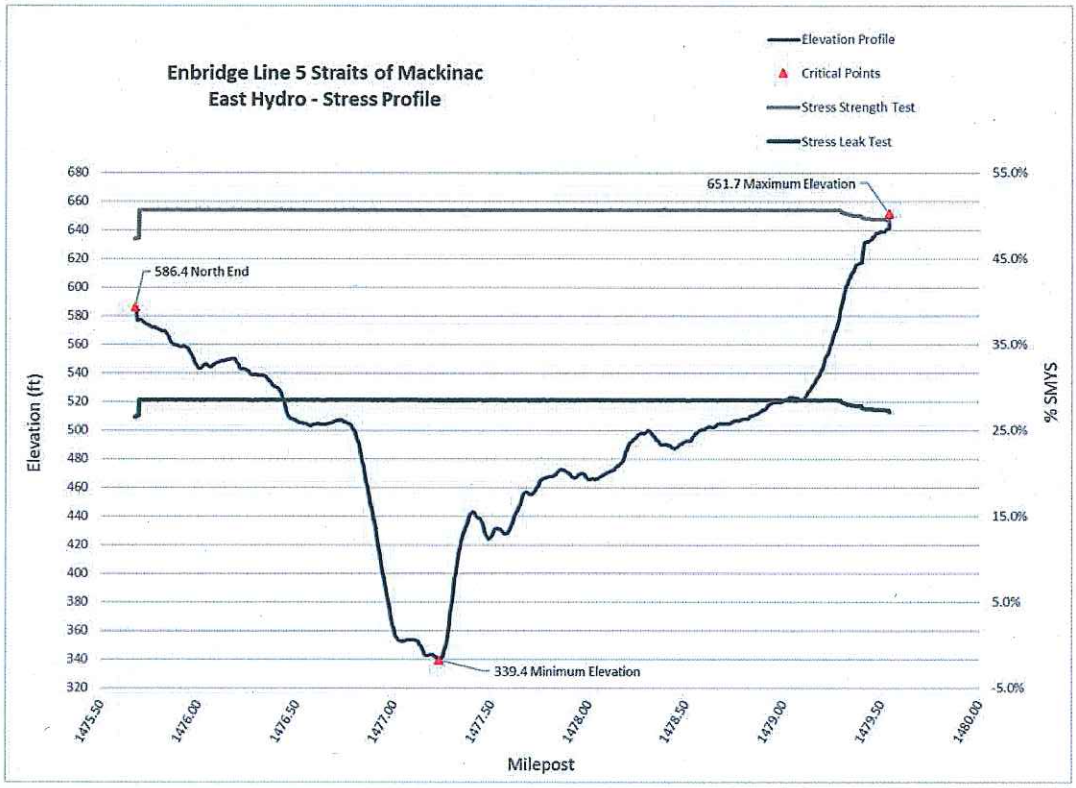
East Straits Segment – Downstream Hydrotest Isolation (E1479.55-5.1-ST-1 & 5.1-CV-1)

2.7. ELEVATION PROFILES






Enbridge Line 5 Straits of Mackinac
East Hydro - Pressure Profile
Elevation Profile
Critical Points
2*MOP
Min Test Pressure Strength
Max Test Pressure Strength
1.1*MOP
Min Test Pressure Leak
Max Test Pressure Leak
651.7 Maximum Elevation
586.4 Test Point
339.4 Minimum Elevation
Elevation (ft)
Pressure (psi)
Milepost


Enbridge Line 5 Straits of Mackinac
East Hydro - Stress Profile
Elevation Profile
Critical Points
Stress Strength Test
Stress Leak Test
651.7 Maximum Elevation
586.4 North End
339.4 Minimum Elevation
Elevation (ft)
% SMYS
Milepost

3. TEST PROCEDURE OUTLINE

3.1. INSTRUMENT CALIBRATION REQUIREMENTS

Enbridge's Operations and Maintenance Manual requires test equipment calibration certificates that shall include the model, serial number, date of certification and shall be signed by a third party testing Company. The original calibration certificates shall be issued to the Company for review prior to testing. Copies of the certificates shall be included in testing documents turned over upon completion of testing.

Instrument	Calibration Interval (months)	Accuracy	Sizing
Deadweight Tester	12	0.1% of Indicated Pressure	Between 25% and 90% of the Full Range of the Instrument
Pressure Gauge	12	±0.5% of Full Scale Range	Pressure Dial Gauges with 6" Minimum Diameter Face with a Range and Scale Increment Suitable for the Test Parameters
Pressure Recorder	12	±1% of Full Scale Range	Between 25% and 90% of the Full Range of the Instrument
Temperature Recorder	12	±2% of Full Scale Range	
Liquid-in-Glass Thermometer	lifetime	±1% of Full Scale Range	Mercury Thermometer with Increments of 1°F Capable of Accurately Measuring the Full Range of Temperatures Anticipated During the Test.
Other Instruments (e.g. flow meters)	12	±1% of Full Scale Range	

Table 3 Instrumentation Calibration Requirements

3.2. TEST INSTRUMENT SETUP

For connecting test instruments for a typical pressure test, see Figure 1.

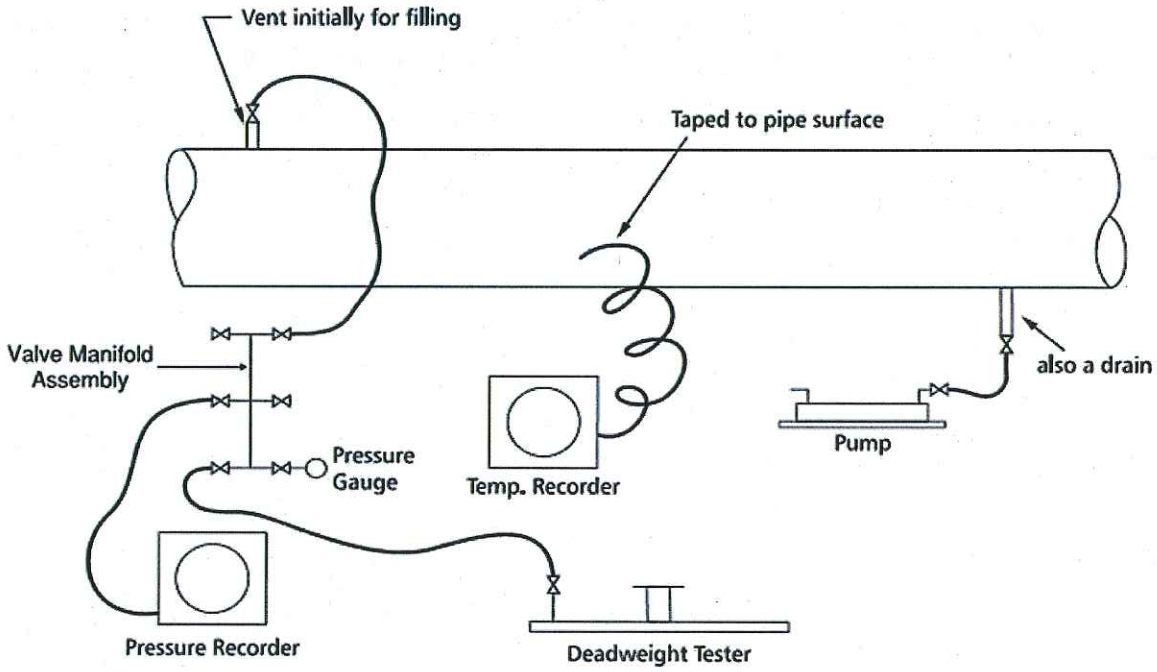


Figure 1
Typical Test Instrument Setup

To ensure the piping is under pressure, separate connections will be made for pressurizing the piping and for recording pressures. The depressurizing point will be different from the point for instrument connections because fluctuations during depressurization may affect the readings.

The test trailer will be set up at the test site on the north end of the straits and the test will be conducted from this location.

The test pressure will be logged from the deadweight tester, which will be set up in the test trailer.

The test pressure will also be continuously recorded on two pressure recorders. One pressure recorder will be placed in the test trailer on the north end and one will be connected to the trap on the south end.

Test pressure will be monitored on each end by a pressure gauge in the test trailer on the north end and on the trap on the south end.

The test medium temperature will be taken as a pipe temperature from a probe that is attached and insulated to the pipe surface. The pipe temperature recorders shall also be a minimum of one-hundred feet from any above grade piping. Two pipe temperature recorders will be used for below grade piping, one will be placed on the north end of the straits and one on the south end. Two pipe temperature

recorders will also be used for above grade piping, one will be placed on the north end of the straits and one on the south end.

The ground temperature will be taken at the same location as the below grade pipe temperature recorders. The temperature probe will be placed at the centerline depth of the pipe and three feet from the outside wall of the pipe. Two ground temperature recorders will be used, one will be placed on the north end of the straits and one on the south end.

The ambient temperature will be taken outside of the test trailer. The probe will be placed under the test trailer to avoid fluctuation from direct sunlight.

The specific locations where instrumentation will be placed to conduct the hydrotest are identified in Tables 4-5 and Figure 2.

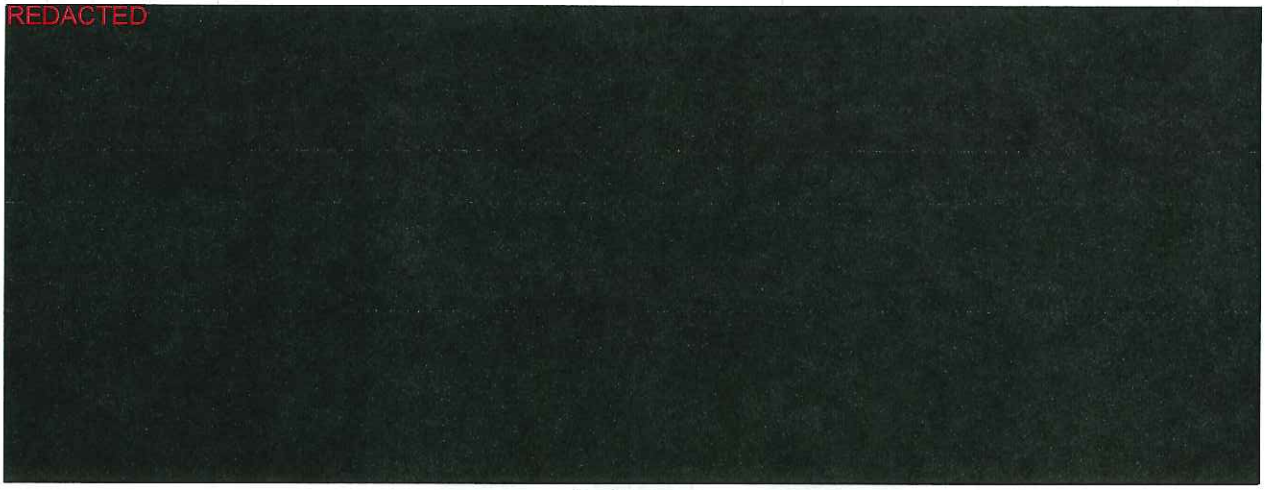
Instrumentation	Mile Post	Stationing
[redacted]	REDA	[redacted]
[redacted]	CTED	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Table 4 West Straits Recorder Locations

Instrumentation	Mile Post	Stationing
REDACTE	[redacted]	[redacted]
D	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Table 5 East Straits Recorder Locations

West Segment



East Segment

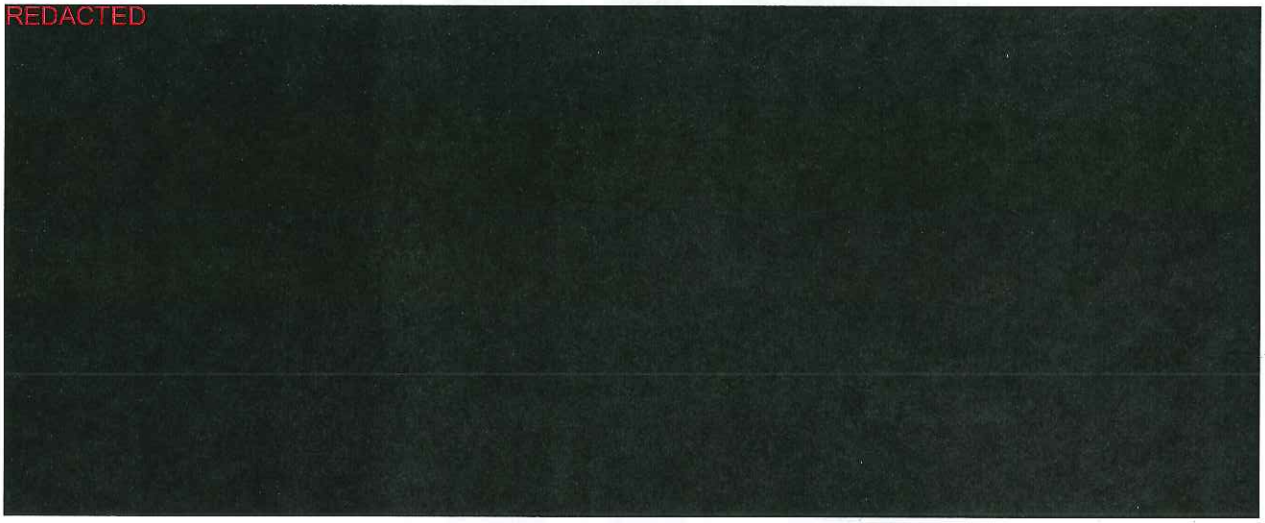


Figure 2 Recorder Location Schematic

3.3. PRESSURE MEASUREMENTS

The accuracy of pressure recorders and pressure gauges will be checked against the deadweight tester at the start and end of the test, at values corresponding to approximately 0%, 50%, 75% and 100% of the test pressure. Deadweight pressures will be logged during the test, at 15 minute intervals on the Pressure Test Data Sheet.

3.4. TEMPERATURE MEASUREMENTS

Pipe, Ground and Ambient temperature recorders will be installed during filling of the pipeline with water to record the temperature change during filling operations. Temperature will be continuously recorded throughout the stabilization period before the tests commence. Comparison of the Pipe and Ground temperatures will be used to determine if the water has stabilized with the ground temperature. In addition, rate of change of the pressure in response to temperature measurements will also be used to determine stabilization. If the water has not stabilized, temperature recording will be continued until the segment has reached stabilization. Temperatures will be recorded continuously throughout the hydrotest. Temperatures will be logged at the same times as the pressure readings at the hold points and every 15 minutes throughout the test.

3.5. PROCEDURE FOR STRENGTH/LEAK TESTING

3.5.1. WATER ACQUISITION

Hydrotest water will be acquired from a local municipality, delivered to the site of the hydrotest and stored in an above ground storage tank (AST). All work will be completed within approved workspace limits.

3.5.2. PRESSURIZATION AND TESTING

1. Ensure temporary piping used for line fill is adequately designed, installed and inspected.
2. The North section of the segment will be isolated from the pipeline by removing a mainline valve and installing two blind flanges.
3. Oil will be removed from the test segment by purging the segment with Nitrogen. This will minimize the oil and water interface.
4. The South section of the segment will be isolated from the pipeline by removing a check valve and installing two blind flanges. Fill test section with test medium (water) from the upstream end.
5. Partially close (50%) any valves in the test section.
6. Bleed any air in test section after filling the traps to ensure a full water column during testing.
7. After filling has been completed, the test section shall be allowed to stabilize at no more than fifty percent (50%) of the test pressure until a temperature-time plot is asymptotic to the ground temperature or a period of twenty-four (24) hours, whichever is longer, as verified by the Company Test Engineer. Pressure and temperature recorders shall be started prior to pressurization and run throughout the stabilization period to ensure proper stabilization has taken place before starting the hydro-test.
8. Visually inspect all above ground mechanical joints (e.g., flanges, fittings and seals) and exposed welds for leaks. Do not visually inspect exposed connections for leaks during rain or after dark without adequate protection and lighting. If the test section is hoarded or covered, ensure there is easy access for visual inspection.
9. New charts shall be placed in the pressure and temperature recorders after the initial stabilization period and prior to beginning the pressurization procedure. The valve manifold assembly (Fig. 1) shall be isolated and dead weights and pressure recorders bled off to zero (0) psig for a fifteen (15) minute hold. Pressure will be re-established to chart recorder and dead weights up to fifty percent (50%) of test pressure for a fifteen (15) minute hold.
10. Begin a pressure-volume (PV) plot at 75% of the strength test pressure and plot to strength test pressure. Pressurization rate shall not be more than a ten (10) psi increase per minute, unless otherwise approved by the Company. See Table 2 for test pressure range.

11. Once the specified test pressure is reached the pressure pump shall be shut down, the valve on trap closed, and the pump disconnected. After the valves have been closed, inspect all visible piping for leaks and then begin the test period.
12. On starting the test, recorders must be checked for correct operation. They must be checked again at least every hour during the test.
13. The test shall be held at the specified test pressure for a continuous eight (8) hour period. Buried pipe shall be tested for a minimum of eight (8) hours starting with a four (4) hour strength test and followed by a four (4) hour leak test. During the strength test, remove test medium to maintain test pressure within acceptable limits. Measure the volume of any test medium removed, and record the amounts on the Pressure Test Report Form.
14. If there are any changes in pressure corresponding to a change in test medium temperature during the test, calculate the relationship between pressure to test medium temperature (see Enbridge's Operations and Maintenance Manual 07-03-04 Calculating Pressure-Temperature Reconciliation).

3.5.3. TEST ACCEPTANCE

3.5.3.1. Strength Test

Maintain test pressure for the duration identified above in Table 2 Test Pressure and Duration.

The strength test is accepted if over the test duration the test pressure remains within acceptable limits as outlined in Table 2 (20psi). Pressure changes can be reconciled with temperature or volume changes according to Enbridge's Operations and Maintenance Manual 07-03-03 Calculating Theoretical Pressure-Volume Relationship and 07-03-04 Calculating Pressure-Temperature Reconciliation.

3.5.3.2. Leak Test

Maintain test pressure for the duration identified above in Table 2 Test Pressure and Duration.

The leak test is accepted if over the test duration the test pressure remains within acceptable limits as outlined in Table 2 (20psi), and any pressure changes can be reconciled with temperature or volume changes according to Enbridge's Operations and Maintenance Manual 07-03-03 Calculating Theoretical Pressure-Volume Relationship and 07-03-04 Calculating Pressure-Temperature Reconciliation.

3.5.4. DEPRESSURIZATION/DEWATERING

1. Ensure temporary piping used for dewatering is adequately designed, installed and inspected.
2. Begin depressurizing as soon as possible after test acceptance.
3. Discharge water using a designated valve on the trap away from the connection to the pressure reading instrumentation. Only qualified personnel shall be permitted to open depressurizing valves. Extreme caution and care shall be used during this operation. The pressure shall be reduced at a controlled rate, as directed by the Company, to ensure that no vibrations develop. Depressurization below 500 psi may not exceed 90 psi per minute.
4. Discharge piping will be connected to the above ground storage tank (AST). The AST will store the water for future use or discharge.
5. Hydrotest water will be reused between test segments, but will be treated onsite utilizing a carbon treatment unit, traditionally equipped with filter bag(s), carbon filters, pressure gauges, sample ports, piping and valves.

6. Upon completion of the final test segment, hydrotest water will be treated onsite via the method stated above. From the AST, water will be delivered via tanker truck to a local municipality wastewater treatment plant for final disposal.

4. CONTINGENCY PLANS

4.1. PREVENTION

A check will be completed of the pressure ratings and condition of components that are not part of the system tested but that are under the test pressure to ensure components are not subject to pressure greater than 90% rated pressure (e.g., pressurizing pump, piping to the test point, expansion tank, test manifold, gauges and fittings).

Appropriate precautions will be made to ensure system components are not over pressured. For example, higher pressures may build up if a valve is closed, especially if the pump connection is separated from the test instruments.

Product will be removed and flushed from the pipeline during the purge and water fill to minimize potential contamination in the event of a test failure.

4.2. EMERGENCY RESPONSE

In the unlikely event of a test medium release during the hydrotest, Emergency Response preparations will be in place. An Incident Action Plan (IAP) will detail the objectives of the overall response, including resources of both people and equipment, and the tactics that will be utilized to respond to a release of test medium during the test. The tactics utilized will be drawn from Enbridge's Tactical Response Plan for the Straits of Mackinac including the establishment of an Incident Command Post and Oil Spill Response Organization (OSRO) Contractor support.

4.3. LEAKS

During the pressurization process leaks will be detected by using the Pressure Volume Plot (PV Plot). During the hydrostatic test any change in pressure will be reconciled by temperature as stated in section 3.5.3. If a leak occurs during the strength or leak test and the test pressure cannot be maintained above minimum test pressure, the test will be stopped. Enbridge will repair the leak and then re-start both the strength test and the leak test.

For leaks that cannot be repaired by rethreading or reflanging a connection see section 4.4 Test Failures.

Enbridge will also comply with Paragraph 26 of the Consent Decree in the event of any leak or rupture that may occur as a result of the hydrotest.

4.4. TEST FAILURES

1. In the event of a test failure during a strength or leak test, the pipe shall be repaired, and both the strength test and the leak test shall be repeated.
2. The Company shall maintain sufficient standby personnel and equipment on site for the repair of leaks. Within ninety (90) days of the test failure, Enbridge shall complete and submit to the EPA and PHMSA an investigatory report of the pipeline failure.
3. Leaks or breaks occurring in the pipe wall or in the pipe seam above the water line of the Straits crossing shall be repaired according to Enbridge's Operations and Maintenance Manual 05-03-08 Determining Remediation Method.

4. Leaks or breaks occurring in the pipe wall or in the pipe seam below the water line of the Straits crossing shall be repaired according to Enbridge's Operations and Maintenance Manual Subsea Repair Section Book 3 Tab 6.

4.5. SAFETY PRECAUTIONS

All work will be conducted in accordance with Enbridge's Liquid Pipelines and Major Projects Safety Manual.

4.5.1. SIGNAGE

For mainline pressure tests, place warning signs that read 'DANGER—PIPE LINE UNDER HIGH PRESSURE TEST' at all access roads 1 day before the test, and on Company property on the day of the test. Keep warning signs in place until after the pipeline has been depressurized.

4.5.2. PUBLIC/WORKER SAFETY

All workers not directly involved in the pressure test should remain a minimum of 15 m (50 ft) from the pipe section under test by signs, fencing and/or verbal warnings.

All landowners along the pipeline route will be notified of the hydrotest taking place. For residences with in 100ft of the pipeline an offer will be made to stay in a local hotel during the testing of the pipeline.

5. SCHEDULE

5.1. WEST SEGMENT

5.1.1. DAY ONE

1. Line 5 Shutdown
2. Drainup and Isolate North End
3. Make Connections for Nitrogen Pumper

5.1.2. DAY TWO

4. Purge Oil Out of West Segment With Nitrogen
5. Blowdown Nitrogen Pressure on Pipeline

5.1.3. DAY THREE

6. Line 5 Shutdown
7. Drainup and Isolate South End

5.1.4. DAY FOUR

8. Line Fill With Water
9. Water Temperature Stabilization

5.1.5. DAY FIVE

10. Water Temperature Stabilization

5.1.6. DAY SIX

11. Water Temperature Stabilization

5.1.7. DAY SEVEN

12. Hydrotest Execution
13. Dewatering of Hydrotest Water

5.1.8. DAY EIGHT

14. Line 5 Shutdown
15. Remove Isolation
16. Make Connections for Nitrogen Pumper

5.1.9. DAY NINE

17. Nitrogen Prepack
18. Oil Line Fill
19. Return to Regular Service

5.2. EAST SEGMENT

5.2.1. DAY ONE

1. Line 5 Shutdown
2. Drainup and Isolate North End
3. Make Connections for Nitrogen Pumper

5.2.2. DAY TWO

4. Purge Oil Out of East Segment With Nitrogen
5. Blowdown Nitrogen Pressure on Pipeline

5.2.3. DAY THREE

6. Line 5 Shutdown
7. Drainup and Isolate South End

5.2.4. DAY FOUR

8. Line Fill With Water
9. Water Temperature Stabilization

5.2.5. DAY FIVE

10. Water Temperature Stabilization

5.2.6. DAY SIX

11. Hydrotest Execution
12. Dewatering of Hydrotest Water

5.2.7. DAY SEVEN

13. Line 5 Shutdown
14. Remove Isolation
15. Make Connections for Nitrogen Pumper
16. Nitrogen Prepack

5.2.8. DAY EIGHT

17. Oil Linefill
18. Return to Regular Service