Enbridge Consent Decree – Civil Action No. 1:16-cv-914
Independent Third Party Review and Evaluation of Enbridge Submittal: Section VII.G. Paragraph 102
Rupture Detection System Test Report

October 23, 2017

Prepared by:

O.B. Harris, LLC
Independent Third Party

Prepared for:

The United States
Environmental Protection
Agency

Written by:	Russel Treat
Reviewed by:	Dan Spangler Larry Shelton Jeryl Mohn
Approved by:	O.B. Harris

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O.B. Harris, LLC, the appointed Independent Third Party (ITP) under the proposed Enbridge Consent Decree (CD), has prepared this report at the request of the Environmental Protection Agency (EPA) and pursuant to CD requirements. In assessing Enbridge's compliance with the CD and in preparing this report, the ITP relied in part on data and information provided by Enbridge. The ITP, though, cannot be responsible for any errors or omissions in this report that are a result of errors or omissions in the data and information provided by Enbridge. This report, and the assessment reflected herein, supersedes any report previously issued by the ITP.

Definitions

Item	Definition
AOPL	Association of Oil Pipe Lines
Accuracy	Defined in API RP 1130 as a measure of the ability of a leak detection system to accurately estimate the leak flow rate, total volume lost, and leak location.
API	American Petroleum Institute
API RP	API Recommended Practice
CPM	Computational Pipeline Monitoring. Refers to the software that monitors pipeline instrumentation to detect leaks.
IT	Information technology
LDAM	Leak Detection Alarm Manager. Refers to a software application within the Enbridge SCADA system that annunciates, tracks, and routes leak alarms to appropriate members of the Alarm Response Team (CD ¶105) and provides capability for working leak alarms.
MBS	Material Balance System. Refers to the CPM in place at Enbridge to detect leaks.
MBS Segments	A defined term in CD ¶88 that refers to each segment of pipeline between two adjacent flow meters.
MOC	Management of Change. Refers to a formal process for implementing change to a pipeline system.
PCSLD/CCO	Pipeline Control Systems and Leak Detection/Control Centre Operations
RDS	Rupture Detection System. Refers to the software application within the Enbridge leak detection system that monitors SCADA to detect pipeline ruptures.
Reliability	Defined in API RP 1130 as a measurement of the ability of a leak detection system to render accurate decisions about the existence of a leak on a pipeline.
Robustness	Defined in API RP 1130 as a measure of a leak detection system's ability to continue to function and provide useful information, even under changing conditions of pipeline operation or in conditions where data is lost or suspect.
RRP	Rupture Recognition Program. An Enbridge project.
SCADA	Supervisory Control and Data Acquisition. Refers to the combination of field automation, telemetry, and host software used to monitor and control geographically distributed facilities.
Sensitivity	Defined in API RP 1130 as a composite measure of the size of a leak that a system is capable of detecting and the time required to issue an alarm if a leak of that size should occur.
SSA	Single Station Algorithm. Refers to the RDS logic and tuning parameters used by the RDS to detect a rupture.

Item	Definition
SSA Parameters	Refers to the specific data elements used in the SSA to identify a rupture. These data elements are tuned by Enbridge engineers to establish SSA performance.
Steady State	A defined term in CD ¶10.jjj that refers to "the pipeline hydraulic condition that exists when all the pipeline operating parameters remain nearly constant over time."
Transient-State	A defined term in CD ¶10.mmm that refers to "the operational condition when oil is moving through a pipeline, or section of pipeline, at a rate or pressure that is in flux."

Executive Summary

The ITP for the Enbridge CD, O.B. Harris, LLC, was engaged effective January 11, 2017. The role of the ITP per the CD is to conduct a comprehensive verification of Enbridge's compliance with the requirements of the CD.[1]

On August 18, 2017 Enbridge submitted the original *Rupture Detection System Test Report Version 1.0* (*RDS Test Report*) to the EPA, as required by CD ¶102.c. On September 7, 2017, the EPA requested that the ITP review and evaluate the *RDS Test Report*, and prepare and provide a written report of its evaluation of the *RDS Test Report.*

CD ¶102.c requires that Enbridge:

- Within 90 Days of the CD Effective Date, submit to EPA the results of testing the Rupture Detection Alarm System for at least two separate Material Balance System (MBS) Segments.
- Document compliance with CD ¶102 (in its entirety).
- Explain why the Rupture Detection Alarm System[2] would alarm in the event of a sudden pressure drop both sides of a pump station.

On August 28, 2017, the ITP requested additional information from Enbridge regarding the *RDS Test Report* and the RDS. In response, Enbridge provided the *Enbridge Response to the ITP's Information Request on p.102 Rupture Detection System Version 1.0* (*First Information Response)* on September 13, 2017, and subsequently provided the *Enbridge Response to the ITP's Information Request on p.102 Rupture Detection System Version 2.0 (Second Information Response)* on September 29, 2017. Enbridge provided a further response to the ITP's preliminary findings in the document entitled *Enbridge Response to September 25, 2017 ITP Preliminary Findings on Consent Decree RDS report (Paragraph 102)* dated October 13, 2017 *(Response to Preliminary Findings)*. These four documents are collectively referred to in this report as the *RDS Reports.*

Findings: The ITP evaluated the *RDS Reports* and finds that Enbridge has not fulfilled certain CD requirements. Specifically, the ITP finds that Enbridge omitted the capability to detect an abnormal increase in flow rate as a feature of the Rupture Detection System (RDS), and as a result has not fulfilled all of the requirements of CD ¶102, CD ¶102.a, CD ¶102.c, and CD ¶102.e.

Observations: In addition to this finding, the ITP offers the following observations regarding the design and implementation of the RDS:

- Rupture detection is a relatively new science in pipeline leak detection, and the RDS implementation at Enbridge is state of the art and generally follows the industry practice recommended in the white

[1] CD ¶125.
[2] Rupture Detection System Alarm and Rupture Detection Alarm System are used interchangeably in the CD and this report but both refer to the same Rupture Detection System (RDS).

paper entitled *Liquid Rupture Recognition and Response* published jointly by the American Petroleum Institute (API) and the Association of Oil Pipe Lines (AOPL) in August 2014.

- The Single Station Algorithm (SSA) rupture detection algorithm was developed and tuned using data consisting of six historical ruptures and 90 simulated ruptures. In discussions with Enbridge on October 17, 2017, Enbridge described the specifics of the test data to the ITP. It was determined that Enbridge did not consider conditions where a rupture occurred with an abnormal increase in flow rate but with no abnormal pressure signature. Therefore, the ITP has reached the following conclusions regarding the RDS implementation:

  1. The RDS would likely detect a rupture of a similar pressure signature as the four historical ruptures delineated in the *Second Information Response*.
  2. The ITP cannot assert that all ruptures would be detected.
  3. The ITP verified that the large data set used by Enbridge to develop and tune the SSA exists, and the ITP developed an understanding of the data content. However, the ITP did not perform any analysis beyond the information provided by Enbridge in the *RDS Reports*.
  4. The ITP cannot provide any assessment of the RDS in terms of sensitivity, accuracy, or robustness.
  5. In the specific case of a rupture downstream of a pump on pressure control, and where the size of the rupture was not great enough to relieve back pressure, it is possible to experience an abnormal increase in flow rate without an abnormally low pressure or an abnormal pressure drop.

Introduction

The ITP for the Enbridge CD, O.B. Harris, LLC, was engaged effective January 11, 2017. As requested by EPA, the ITP has reviewed and evaluated the Enbridge *Rupture Detection System Test Report Version 1.0* (*RDS Test Report*) that Enbridge submitted to the EPA on August 18, 2017 pursuant to the requirements of the CD.

The ITP had the following exchanges with Enbridge and the EPA subsequent to submission of the August 18, 2017 *RDS Test Report*.

- On August 28, 2017, the ITP transmitted the *RDS Test Report – Additional Information Request* to Enbridge and the EPA.
- On September 7, 2017, the EPA requested that the ITP evaluate the *RDS Test Report* and prepare this report. In accordance with CD ¶132.b, this report is due within 45 days of the EPA's request or October 23, 2017[3].
- Enbridge replied to the ITP's request on September 13, 2017 with the *Enbridge Response to ITP Information Request on p.102 Rupture Detection System Version 1.0 (First Information Response).*
- On September 25, 2017, the ITP presented the *RDS Test Report – ITP Preliminary Findings* to Enbridge and the EPA which outlined six preliminary findings.

Enbridge replied to these preliminary findings on September 29, 2017 with the *Enbridge Response to ITP Information Request on p.102 Rupture Detection System Version 2.0 (Second Information Response).*

- Enbridge provided a further response to the ITP's preliminary findings in an October 13, 2017 document entitled *Enbridge Response to September 25, 2017 ITP Preliminary Findings on Consent Decree RDS report (Paragraph 102) (Response to Preliminary Findings)*.
- In an October 17, 2107 meeting in Edmonton, the ITP, Enbridge, and the EPA discussed the RDS implementation and the information provided by Enbridge in its *Response to Preliminary Findings*.

The four documents that Enbridge transmitted to the EPA and the ITP are collectively referred to as the *RDS Reports* throughout this report.

Summary of the Consent Decree Requirements

The ITP is required to review and evaluate all proposed plans, reports, and other deliverables that Enbridge is required to submit to the EPA under the CD. CD ¶132.b also provides that the ITP shall review and evaluate the completeness of the Enbridge submittal and its compliance with the requirements of the CD. CD ¶134.e requires that the ITP assess whether Enbridge submittals are supported by the facts and best engineering judgment. CD ¶132.b states that, if the EPA requests, the ITP is to submit to the EPA a written report of its evaluation within 45 days of the request.

[3] Inasmuch as 45 days from the EPA request, October 22, occurred on a Sunday, this report is timely submitted the following business day (CD ¶10.m).

CD section VII.G, ¶102.c requires that within 90 days of the CD Effective Date (May 23, 2017), or no later than August 18, 2017, Enbridge submit to the EPA the results of testing the Rupture Detection Alarm System. Further, CD ¶102.c requires the testing of the RDS on at least two separate Material Balance System (MBS) Segments, documentation of compliance with the entirety of CD ¶102, and an explanation why the Rupture Detection System (RDS) would alarm in the event of a sudden pressure drop on both sides of a pump station.

CD ¶102.c requires that Enbridge document compliance with the entirety of CD section VII.G, ¶102 including the following:

- Continuous operation of the RDS Alarm System on all Lakehead System pipelines, and during both Steady State and Transient-State (CD ¶102 and CD ¶102.e).
- A computer based system that continuously monitors real-time data to detect the following conditions (CD ¶102.a):
  - An abnormally low pressure
  - An abnormal pressure drop
  - An abnormal increase in flow rate
- Alarm generation, upon detection of one or more of the above conditions, and issuance of an alert to each member of the Alarm Response Team (CD ¶102.b) including:
  - Remote notification of the Alarm Response Team (CD ¶106).
  - Audible and visual alarms (CD ¶107).
- If such testing does not demonstrate compliance, submit a corrective action plan (CD ¶102.e).

Summary of Enbridge *RDS Reports*

Enbridge made a timely submission on August 18, 2017 of the *RDS Test Report.* As described in the Introduction section of this report, Enbridge subsequently submitted to the EPA and the ITP two additional information responses and a response to findings. These four documents are collectively referred to as the *RDS Reports.*

RDS Test Report Summary

Following is a summary of the content, by section, of the *RDS Test Report*.

Introduction

This section of the *RDS Test Report* references CD ¶102 and CD ¶102.c and states that the report satisfies the requirement to submit a report within 90 days of the CD Effective Date.

Background

This section describes the manner in which Enbridge created the RDS. Enbridge initiated a Rupture Recognition Program (RRP) in 2013. Enbridge defines a rupture as:

- A leak of a size that can be detected with a high degree of reliability.
- An RDS that results in, at most, one false alarm per year.

The result of the RRP was used by Enbridge to implement a Supervisory Control and Data Acquisition (SCADA)-based RDS, the objective of which is to:

- Exploit the signatures or patterns of abnormal operating conditions, such as abnormally low pressure and abnormal pressure drop, that may be indicative of a rupture.
- Use available SCADA telemetry to systematically identify those patterns and generate reliable alarms.

Upon identification of a signature which is indicative of a rupture, the RDS executes the following actions:

- Provides an alarm to the control room operator.
- Provides an alarm to all members of the Alarm Response Team.
- Initiates an automatic emergency shutdown of the affected pipeline.

RDS Algorithm

This section describes the algorithm used to identify a rupture signature. The algorithm used in the Enbridge RDS is called the Single Station Algorithm (SSA). This algorithm uses SCADA measurements from each pump station independently, i.e., each pump station is analyzed in isolation from other stations. Inputs to the SSA are:

- Station discharge pressure.
- Station suction pressure.
- Pump unit status.

Using the inputs, the SSA determines attributes. These attributes are described in Table 1 on page 10.

Table 1: SSA attributes and descriptions

Requirement	Notes
Accumulated discharge pressure change	Accumulation based on recursive least squares algorithm
Instant discharge pressure change in 5 seconds	Change between two scans
Equalization pressure	Value to describe if the discharge pressure crosses the suction pressure
Difference between suction and discharge pressures	Value to evaluate if the suction and discharge pressures converge

The attributes are used to inform a complex decision tree, consisting of five outcomes. Each outcome is called a leaf, and each outcome has its own conditions for identifying a rupture signature. The thresholds for the attributes were tuned through iterations of testing historical data.

RDS Continuous Operations

The *RDS Test Report* describes the method for ensuring continuous operation of the RDS. The following is described:

- The hot failover backup system is comprised of a primary and a stand-by system, both of which run simultaneously, with only the active system (primary or backup) generating alarms.
  A failure of the primary RDS causes the backup RDS to automatically take control, and a message is sent to on-call information technology (IT) support for immediate response.
  In the event of failure of both the primary and backup, a system fail alarm is generated to the leak detection analyst and the control room operator.
- Leak detection analysts provide 24/7 support of RDS alarms.
- Line custodians provide routine maintenance tracking of the RDS.
- Line custodians use the RDS dashboard to complete routine maintenance.

Rupture Detection System Testing

The *RDS Test Report* describes the testing performed by Enbridge. Enbridge compiled a data set of operational information from historical ruptures and more than 200 simulated leaks and ruptures. Data included:

- 26 lines
  - 2 years of data for 22 lines
  - 1.5 years of data for 1 line
  - 1 year of data for 3 lines
- 256 stations

- Thousands of operational events including:
  - Transient conditions
  - Start-up
  - Shutdown

The SSA was tuned and run with the test data set; testing generated three false alarms. Enbridge states that this result meets the reliability target expressed in the Background section of the *RDS Test Report*, namely “at most, one false alarm per year.”

Enbridge stated that they created simulated leaks over a range of operating conditions.

Enbridge created a custom-built testing environment and used the outcomes from testing to ensure compliance with the requirements of the CD.

In accordance with CD ¶102.c, historical data for two Lakehead System MBS Segments were selected by Enbridge for testing, specifically:

- Line 14 Adam Station (AM), 2012 Line 14 release
- Line 6B Marshall station (MR), 2010 Line 6B release

MBS Segment Rupture Test Results

The RDS Test Report provides a summary of the test results for the two historical ruptures noted above. Table 2 provides a summary of the test results.

Table 2: RDS test results

Line	Station	Time	Pressures Before Rupture (psi)	Pressures 1 Min After Rupture (psi)	Pressures Change in 5 Sec (psi)	Time to Detect Rupture (sec)
14	AM	2012 07/27	Discharge: ~1330 Suction: ~590	Discharge: ~100 Suction: ~130	Discharge: -787 Suction: -267	10
6	MR	2010 07/25	Discharge: ~480 Suction: ~200	Discharge: ~1 Suction: ~3	Discharge: -250 Suction: -108	10

The attributes that triggered the RDS alarms were as follows:

- Line 14, Station AM: extreme sudden discharge pressure change (large rate of change), which is indicative of a rupture based on the tuned threshold.

- Line 6, Station MR: a combination of the calculated rate of change along with the low equalization suction and discharge pressures relative to the tuned thresholds.

Summary

Enbridge states the following:

- The RDS was implemented prior to the CD Effective Date.
- The RDS is continuously operated.
- The RDS generates an alarm if abnormal conditions are identified during both Steady State and Transient-State conditions.
- RDS generated alarms alert the control room operator and all members of the Alarm Response Team of a rupture, and the RDS proceeds to automatically initiate a shutdown of the affected pipeline.
- In accordance with CD ¶102.c, Enbridge has tested two separate MBS Segments to confirm RDS operations as required under CD ¶102 to continuously monitor Enbridge pipelines during Steady State and Transient-State conditions.
- The RDS reliably detects a rupture based on one or more of the following conditions:
  - Abnormally low pressure
  - Abnormal pressure drop
- Enbridge testing demonstrates that the RDS can detect a rupture and generate an alarm within 10 seconds of the rupture event while generating minimal false alarms.

First Information Response Summary

Table 3 is a summary of the content of the *First Information Response*:

Table 3: *First Information Response* summary

Content Item	Description
A copy of and a detailed description of the SSA	Included: • A diagram of the SSA • Description of parameters • Description of each SSA outcome indicating a rupture
Specification of the thresholds and variables in the SSA decision tree with information that explains and supports how the thresholds were determined	Provided: • Criteria for determining thresholds • A description of the historical data used for testing

Content Item	Description
Test protocols and related certification for tests to demonstrate compliance for the six abnormal conditions described in the CD	Provided: • A description of the testing rationale • Details of four historical ruptures used to tune the SSA parameters
Test data and results for each of the six abnormal conditions on both lines	Provided: • A description of the testing rationale • The scope of test data used
Explain why the RDS would alarm in the event of a sudden pressure drop of both sides of a station	Provided the SSA outcomes that would identify this condition
Statement of in-service date for the RDS	Provided the RDS in-service date by line segment with the related Management of Change (MOC) reference
Evidence to support continuous operation since the CD Effective Date	Provided a description of evidence of continuous operation
Evidence to support operation of the system to include alarm annunciation through an alarm response	Provided example software application displays and reports for an RDS alarm that occurred in August 2017
Evidence supporting proper operation of the hot failover backup system	Provided an MOC document demonstrating testing of the backup RDS
Evidence supporting compliance with CD ¶106 and CD ¶107 • Remote notification of alarm team • Audible and visual alarms	Provided: • Example Leak Detection Alarm Manager (LDAM) screens • A software data flow diagram

Second Information Response Summary

The *Second Information Response* provided additional information demonstrating that the RDS would detect four historical ruptures representing the following four abnormal cases:

- Steady State – abnormal pressure drop
- Transient-State – abnormal pressure drop
- Steady State – abnormally low pressure
- Transient-State – abnormally low pressure.

Response to Preliminary Findings Summary

The *Response to Preliminary Findings* addressed each of the ITP's preliminary findings and presented the basis for not using flow rate (i.e., an abnormal increase in flow rate) in its RDS algorithm, as follows:

- Enbridge states that it "reasonably interpreted [CD] ¶102a to allow it to design a rupture alarm system that does not include in its algorithm all three of the listed factors"[4] (i.e., abnormal pressure drop, abnormally low pressure, and abnormal increase in flow rate).
- Enbridge did not implement an RDS algorithm using a combination of all three conditions since they concluded that doing so "has a risk of compromising the sensitivity of the system by delaying the identification of a rupture or missing the identification of a rupture event." [5]
- Enbridge stated that "a flow condition was later added into the original algorithm to create a new algorithm which increased reliability for certain non-Lakehead lines by considering flow measurement data."[5] In discussion with Enbridge on October 17, 2017, it was determined that flow was used as a confirmation of a pressure change indicating a rupture as a mechanism to eliminate false alarms, and that flow was not used to indicate a rupture independent of pressure.
- Enbridge stated that "an abnormal increase in the flow rate is not a mutually exclusive rupture event that would be detected in the absence of an abnormally low pressure or abnormal pressure drop." [6]
- Enbridge stated that "most flow computers also apply a smoothing to the signal, which in turn delays the spike and can cause a delayed or missed rupture. Enbridge determined that the risk of a delayed or missed rupture was unacceptable".[6]
- Enbridge provided information to confirm the ability of the RDS to detect a rupture in the following four cases:
  - Steady State – abnormally low pressure
  - Transient-State – abnormally low pressure
  - Steady State – abnormal pressure drop
  - Transient-State – abnormal pressure drop

[4] *Response to Preliminary Findings*, page 1.
[5] *Response to Preliminary Findings,* page 2.
[6] *Response to Preliminary Findings,* page 3.

Analysis of the Enbridge *RDS Reports*

Scope

In its analysis of the *RDS Test Report*, the ITP applied the following standards that are described in the CD:

1. Evaluate the *RDS Test Report*'s compliance with the prescriptive requirements of the CD.[7]
2. Evaluate whether the *RDS Test Report* is supported by the facts and best engineering judgment and is of sufficient detail and completeness so that the expected outcome will be achieved.[8]

The ITP's review and analysis did not include:

- Review or analysis of the large data sets used to develop and tune the SSA.
- An assessment of the size of leak that would or would not be detected by the RDS.

Analysis of the RDS Reports

General

The ITP considers rupture detection to be a relatively new 'science' in pipeline leak detection. The work performed by Enbridge is, in the opinion of the ITP, state of the art.

Continuous operation of the RDS

(CD ¶102 and CD ¶102.e)

The Enbridge policies and procedures for operation of the RDS were reviewed by the ITP, including a review of publication dates for those documents. In addition, Item 6 in the *First Information Response* provided a statement of in-service dates for the RDS, including a listing of the in-service date for each line within the Lakehead System. The ITP attended meetings with Enbridge in Edmonton, Alberta on July 25th and 26th, 2017. During these meetings, Enbridge provided a demonstration of the RDS and related alarm annunciation through the LDAM. Beginning in August 2017, the ITP participates in monthly meetings where Enbridge presents monthly RDS operation reports.

Continuous monitoring of real-time data to detect abnormally low pressure

(CD ¶102.a.a)

The ITP reviewed the SSA as described in item 1, Decision Tree Logic Flow of the *First Information Response*. The Decision Tree Logic Flow provides for five end points which would indicate a rupture based on various pressure conditions. The ITP reviewed the *Second Information Response* and found that the SSA would detect abnormally low pressure in both Steady State and Transient-State conditions.

[7] CD¶134.b

[8] CD¶134.e

The ITP found that the logic of the SSA will capture an abnormally low pressure within the tuning of the SSA parameters.

Continuous monitoring of real-time data to detect an abnormal pressure drop

(CD ¶102.a.b)

The ITP reviewed the SSA as described in item 1, Decision Tree Logic Flow, of the *First Information Response*. The Decision Tree Logic Flow provides for five end points which would indicate a rupture based on various changes in pressure conditions over a period of up to two minutes. The ITP reviewed the *Second Information Response* and found that the SSA would detect an abnormal pressure drop in both Steady State and Transient-State conditions. The ITP found that the logic of the SSA will capture an abnormal pressure drop within the tuning of the SSA parameters.

Continuous monitoring of real-time data to detect an abnormal increase in flow rate

(CD ¶102.a.c)

The ITP reviewed the SSA as described in item 1, Decision Tree Logic Flow, of the *First Information Response*. The ITP found that the logic of the SSA did not address flow rate, and, as such, that the SSA would not capture an abnormal increase in flow rate. Enbridge acknowledged in the *Second Information Request* that "testing of the addition of an abnormal increase in flow rate to the RDS algorithm was demonstrated to compromise reliability (i.e. an increase in false alarm rates)[9]".

Alarm generation alerting each Alarm Response Team member

(CD ¶102.b)

The ITP reviewed alarm response policy and procedure in the control room. During the demonstration provided by Enbridge at the July 25th and 26th meetings, Enbridge provided a demonstration of the RDS and related alarm annunciation through to the LDAM application. The ITP reviewed the RDS alarm report provided as Item 8 of the *First Information Response*.

Remote notification of the Alarm Response Team

(CD ¶102.b, CD ¶106)

The ITP reviewed the RDS alarm report provided as Item 8 of the *First Information Response*. During the meetings with Enbridge in Edmonton on July 25th and 26th, Enbridge provided the ITP with a demonstration of the leak alarm annunciation through to the LDAM application, including the escalation to a phone call to supervision if the primary Alarm Response Team member did not acknowledge the alarm within two minutes.

[9] *Second Information Request*, page 2.

Audible and visual alarms

(CD ¶102.b, CD ¶107)

The ITP reviewed the RDS alarm report provided as Item 8 of the *First Information Response*. During the meetings with Enbridge in Edmonton on July 25th and 26th, Enbridge provided the ITP with a demonstration of the leak alarm annunciation through to the LDAM application, including the audible and visual alarm indications.

Within 90 days of the CD Effective Date, submit to the EPA the results of testing

(CD ¶102.c)

The *RDS Test Report* was submitted to the EPA via email on August 18, 2017, 90 days following the CD Effective Date of May 23, 2017.

Document compliance with the entirety of CD ¶102

(CD ¶102.c)

The ITP reviewed the *RDS Reports* for compliance with the entirety of CD ¶ 102. In addition, the ITP reviewed policy and procedure documents, user manuals, and reports provided at monthly Pipeline Control Systems and Leak Detection/Control Centre Operations (PCSLD/CCO) meetings for evidence of compliance.

Explain why the RDS would alarm in the event of a sudden pressure drop on both sides of a pump station

(CD ¶102.c)

Item 5 of the *First Information Response* provides the Enbridge rationale for why the RDS would alarm in the event of a sudden drop in pressure on both sides of a pump station. Item 5 specifically states that two of the SSA outcomes, RupLeak.1 and RupLeak.2, indicate a sudden drop in pressure on both sides of a pump station.

In the event of failure to demonstrate compliance, submit a corrective action plan no later than 30 days following completion of corrective action

(CD ¶102.d)

The Summary section of the Enbridge *RDS Test Report* claims compliance with the requirements of CD ¶102.

Continuously operate the RDS including periods of both Steady State and Transient-State

(CD ¶102.e)

The ITP reviewed the SSA as described in Item 1, Decision Tree Logic Flow, of the *First Information Response* and the *Second Information Response.*

Findings and Observations

The ITP evaluated the August 18, 2017 *RDS Test Report* and on August 28, 2017 submitted a request for additional information to Enbridge. Enbridge responded with the *First Information Response* to address the ITP request. Following Enbridge's reply to the ITP request, the ITP briefed Enbridge and the EPA on six preliminary findings. Enbridge responded to the preliminary findings by providing the *Second Information Response* and the *Response to Preliminary Findings*.

Three of the six findings were subsequently resolved and the three remaining findings were revised and consolidated into a single finding. The ITP found Enbridge to be complaint with the CD except for the single finding.

Finding #1

Flow rate is not a variable utilized in the SSA. Therefore, the ITP finds the following:

1. The implementation of the RDS does not meet the requirement to continuously monitor real-time data from the SCADA system to detect an abnormal increase in flow rate (CD ¶102.a).

2. Enbridge has not provided information that would support verification of the RDS for two of the abnormal conditions identified in CD ¶102 and CD ¶102.a:

   - Steady State – abnormal increase in flow rate

   - Transient-State – abnormal increase in flow rate

   Therefore, Enbridge has not provided documentation of compliance (CD ¶102.c).

3. Two abnormal conditions defined in CD ¶102 and CD ¶102.a (Steady State – abnormal increase in flow rate and Transient-State – abnormal increase in flow rate) are not being detected and alarmed by the RDS. Therefore, the RDS was not fully implemented on the CD Effective Date, nor was it continuously operated (CD ¶102.e).

Observation #1

In addition to the above finding, the ITP offers the following observation regarding the design and implementation of the RDS. Rupture detection is a relatively new science in pipeline leak detection. Beginning in 2011, the American Petroleum Institute (API) and the Association of Oil Pipe Lines (AOPL) identified rupture detection as a focus area where the industry had an opportunity to proactively improve its performance. Ultimately, this resulted in the publication of a white paper entitled *Liquid*

Pipeline Rupture Recognition and Response published jointly by the API and the AOPL in August 2014 (*Rupture Recognition White Paper*).

Rupture detection places the emphasis on leak detection reliability (a low false alarm rate) rather than on sensitivity (the size of leak detected). The goal of rupture detection is to provide a highly certain indication so that distinct and immediate rupture response can occur in the pipeline control center. Enbridge follows this guidance. Specifically, the Background section of the RDS Test Report defines a rupture as, "that size of a leak that can be detected with a very high degree of reliability – i.e., a rupture detection system that results in, at most, one false alarm per year."

The federal pipeline safety regulations in 49 CFR § 195.134: *Transportation of Hazardous Liquids by Pipeline* require liquid pipeline operators to follow API Recommended Practice (RP) 1130: *Computational Pipeline Monitoring for Liquids* (API 1130) for each new and replacement Computational Pipeline Monitoring (CPM) component. In addition, 49 CFR §195.444 requires that operators comply with API 1130 in operating, maintaining, testing, record keeping, and dispatcher training of a CPM leak detection system. API 1130 describes the four considerations for selecting and optimizing a leak detection system. In addition to reliability, which is the focus in rupture detection, API 1130 also requires an analysis of sensitivity, robustness, and accuracy. Section 4.1.2 and Annex B of API 1130 provide, respectively, a list and description of internally based CPM system types. Rupture detection is not listed as a CPM type in API 1130.

A key goal stated in the *Rupture Detection White Paper* was to distinguish rupture detection from leak detection to enhance controller response. API 1130 was last reaffirmed in April 2012, while the *Rupture Detection White Paper* was published in August 2014. It is the opinion of the ITP that the *Rupture Detection White Paper* provides the more appropriate guidance for the implementation of rupture detection.

The Enbridge RDS, in the configuration evaluated by the ITP, is designed to provide a highly certain indication of rupture, meaning that if the RDS generates a rupture alarm, it is highly likely that a rupture has occurred. This does not mean that all ruptures are likely to be detected.

Observation #2

The SSA rupture detection algorithm was developed and tuned using test data consisting of six historical ruptures and 90 simulated ruptures. In discussions with Enbridge on October 17, 2017, Enbridge described the specifics of the test data to the ITP. It was determined that Enbridge did not consider a condition where a rupture occurred with an abnormal increase in flow rate but with no abnormal pressure signature. Therefore, the ITP has reached the following conclusions regarding the RDS implementation:

1. The RDS would likely detect a rupture of a similar pressure signature as the four historical ruptures delineated in the *Second Information Response*.

2. The ITP cannot assert that all ruptures would be detected.

3. The ITP verified that the large data set used by Enbridge to develop and tune the SSA exists and developed understanding of the data content. However, the ITP did not perform any analysis beyond the information provided by Enbridge in the *First and Second Information Responses*.

4. The ITP cannot provide any assessment of the RDS in terms of sensitivity, accuracy, or robustness.

5. In the specific case of a rupture downstream of a pump on pressure control, and where the size of the rupture was not great enough to relieve back pressure, it is possible for there to be an abnormal increase in flow rate without an abnormally low pressure or an abnormal pressure drop.

List of Information Considered

The EPA requested that the ITP apply CD ¶133.a and identify all information considered by the ITP, identify all persons interviewed by the ITP, and summarize all relevant oral communications.

Federal Documents and Regulations

49 CFR Part 195: Code of Federal Regulations, Transportation: *Transportation of Hazardous Liquids by Pipeline.*

Consent Decree: *United States of America v. Enbridge Energy, Limited Partnership, et al*; Civil Action No. 1:16-cv-914, effective May 23, 2017.

Industry Standards and Papers

Liquid Pipeline Rupture Recognition and Response. American Petroleum Institute and Association of Oil Pipelines. August 2014.

Recommended Practice 1130: *Computational Pipeline Monitoring for Liquids*. American Petroleum Institute. April 2012.

Enbridge Documents

D12-105 – (2015): Enbridge Design Standard: *Mainline Leak Detection Equipment*, Version 2.0. October 28, 2015.

Enbridge Response to ITP Information Request on p.102 Rupture Detection System, Version 1.0. August 28, 2017.

Enbridge Response to ITP Information Request on p.102 Rupture Detection System, Version 2.0. September 29, 2017.

Enbridge Response to September 25, 2017 ITP Preliminary Findings on Consent Decree RDS report (Paragraph 102). October 13, 2017.

Leak Detection System (LDS) General Manual, Version 1.0. May 11, 2017.

Rupture Detection System Test Report, Version 1.0. August 18, 2017.

Other Communications

In-person meeting. ITP met with Enbridge in Edmonton, Alberta, over the period of July 25–26, 2017.

Meeting. Enbridge, EPA (by phone), and ITP met in Edmonton to discuss the October 13, 2017 submittal, *Response to Preliminary Findings.* October 17, 2017.

Online Meeting. ITP briefed EPA and Enbridge on the preliminary findings from the ITP's preliminary assessment of the original *RDS Test Report*. September 25, 2017.

Presentation. *Monthly PCSLD Technical Meeting.* Presented by Enbridge on August 25, 2017 at the first monthly PCSLD Technical Meeting via teleconference screen share.