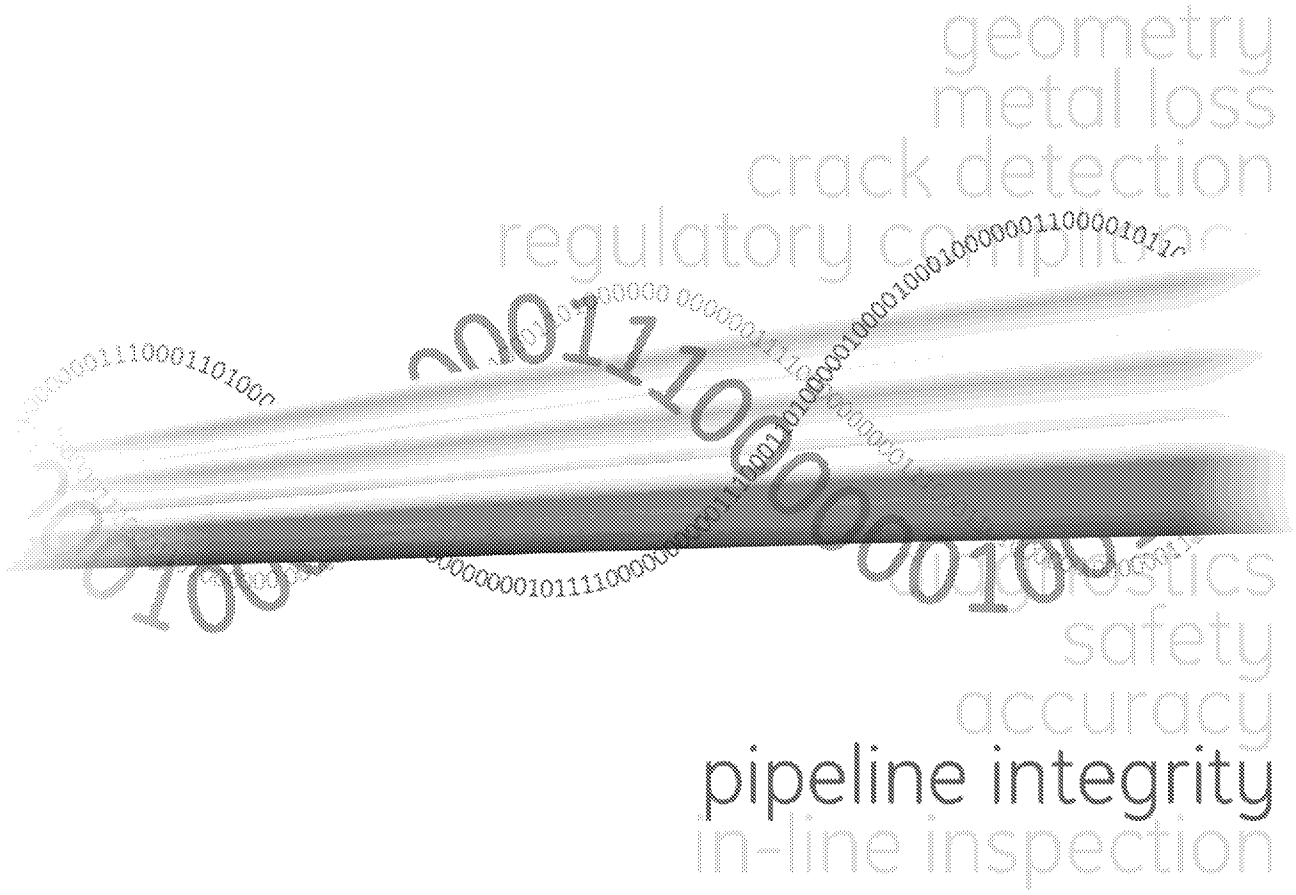
New MagneScan™ Geometry
Inspection Report for
20 inch Crude Oil Pipeline



Enbridge Energy, Limited Partnership

Line 05: 20" West North Straits to West Mackinaw (WNO-WMA)
Run Date: 17 January 2020

Work Order Number: W132012872 R4
Contract Number: 31715
Project Number: 451591_20B
Issue 1, 16 April 2020

Baker Hughes

Executive Summary

A full survey of the Enbridge Energy, Limited Partnership Line 05: 20" West North Straits to West Mackinaw (WNO-WMA) pipeline was successfully completed by Baker Hughes, on the 17th of January 2020. The tool was pulled from the pipeline on the 17th of January 2020. The pipeline survey was performed using Baker Hughes's New MagneScan Geometry (Caliper) and Mapping (IMU) inspection vehicle.

The inspection has confirmed that the pipeline is 4.116 miles long.

The following table summarises the pipeline anomalies identified during the survey.

Feature Type	Quantity	Comment
Dents	3	Deepest: 3.53%OD
Ovalities	0	Maximum: 1.59%OD
ID Reductions	0	
ID Expansions	0	
Wrinkle/Buckle	0	Deepest: N/A%OD
Minimum Internal Diameter		17.499 in

Note: The girth welds for this inspection have been correlated with the baseline listing provided by Enbridge. The draft pipeline listing for this inspection was approved by Enbridge Energy, Limited Partnership on the 14th of April 2020.

Below are the names, roles and certification levels of the analysis team that participated in this project:

Analyst	Role	Certification Level
John Ma	Report Checker	2
Aniko Stamp	QA Checker	2
Martin He	Data Analyst / Report Author	1

This report was generated following the Enbridge ILI Minimum Reporting Requirements Guide V.8.2.

Some data quality issues were experienced during the survey. These are fully described in the Data Quality section.

Mapping data and pipeline marker data (above ground markers) has been collected enabling a complete geo-referencing of the pipeline to be completed in accordance with the agreed specification.

We should hereby like to express our appreciation for the assistance and co-operation that we received from Enbridge Energy, Limited Partnership in the course of this project.

Lead Analyst:	**Martin He** **Level I Caliper**		
Report Approved by:	**John Ma** **Level II Caliper**	**Date:**	**16 April 2020**
Integrity Specialist:	**Ramzan Mohammed**	**Telephone:**	**403-650-5250**
Project Manager:	**Tanis Lindberg**	**Telephone:**	**780-318-1895**

Revision List

Revision Number	Change Details	Date of Re-issue

Distribution List

Name	Title	Company	No. of Copies
Emils Muehlenbachs	Program Manager	Enbridge Energy, Limited Partnership	1
Central File		Baker Hughes	1

Contacting Baker Hughes

Baker Hughes Telephone Numbers:

Project Manager	Tanis Lindberg	
Telephone:	+1-403-262-7447	(CANADA)
Address:	Baker Hughes (BH) 4908 - 52nd Street S.E. Calgary, Alberta T2B 3R2 Canada	

Further Information

In order to augment and fully explain the information within this report, the following information is provided on the HDD with this report.

- Reporting Schedule
- Inspection System Performance Specifications
- Explanation of Report Listings
- Explanation of Report Plots and Histograms
- Explanation of Inspection Sheets
- Definitions of Terminology
- Explanation of Dent and Geometric Feature Measures
- Locating Pipeline Features
- Guidance Notes for Recording Excavations
- MFL Tool Data Sheets (New MagneScan)
- MFL Tool Data Sheets (MagneScan)
- TranScan Tool Data Sheets
- Geometry (Caliper) Tool Data Sheets
- UltraScan WM Tool Data Sheets
- UltraScan CD Tool Data Sheets
- UltraScan Duo Tool Data Sheets
- EmatScan CD Tool Data Sheets
- Integrity Engineering Offerings
  - Length Adaptive Pressure Assessment (LAPA)
  - Corrosion Growth (RunCom)
  - Fitness-for-Purpose Assessment
  - Post Inspection Dent Assessment (PIDA)
  - Strain Assessment
  - Pipeline Integrity Crack Assessment (PICA)
  - Lamination Assessment
  - ERW Seam Weld Assessment

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1. Introduction

This report presents the results of the pipeline inspections survey 451591_20B which was conducted by Baker Hughes for Enbridge Energy, Limited Partnership in the Line 05: 20" West North Straits to West Mackinaw (WNO-WMA), 20 inch diameter, 4.116 miles, Crude Oil pipeline.

The pipeline was inspected by the Baker Hughes New MagneScan Geometry (Caliper) and Mapping (IMU) inspection vehicle on the 17th of January 2020.

This was a reinspection of the pipeline with a previous inspection having been carried out by Baker Hughes on the 14th of March 2019.

The information from the inspection operation has been analysed to enable this report to be produced detailing the condition of the pipeline.

1.1. Inspection Specification

The following information summarises the New MagneScan Geometry (Caliper) and Mapping (IMU) specifications as defined in the contract.

1.1.1. Geometry (Caliper) Specification

The Geometry (Caliper) tool was calibrated by using a calibration ring and simulating deformities with small slabs of material. With the help of this calibration, the measurements of the Caliper were correlated to the actual ID reductions detected. The Geometry (Caliper) detection specification is summarised below:

Feature	Sensitivity at 90% POD (%OD)	Accuracy at 85% Confidence (%OD)	Evaluation Threshold (%OD)
Dents	1.0%	ID_{red} < 6% - ±1.0 % ID_{red} > 6% - ±1.2 %	2%
Ovalities	0.7%	±1.3 %	5%

Features will be located to an axial accuracy of ±0.2m (±8 in) between the feature and the reference girth weld and ±1% of stated distance between reference upstream girth weld and identification location reference. They will be located circumferentially to an accuracy of ±5.0 degrees which for ease of reference is stated to the nearest quarter hour clock position.

Percentage values are based on nominal outside diameter (OD).

These specifications are only applicable when the New MagneScan Geometry (Caliper) tool is run in accordance with the pipeline parameters stipulated in the Operating Schedule.

All reported features have been assessed using Baker Hughes' enhanced Caliper analysis algorithm.

1.1.1.1. Bend Classification

The evaluation of bends is made according to the following classification groups.

Radius Range	Radius Reported
Less than 1.5D	<1.5D *
Less than 3.0D	1.5D
Less than 5.0D	3.0D
Less than 7.0D	5.0D
Less than 10D	7.0D
Less than 13D	10.0D
Greater than 13D	Field (Cold) Bend

** Further investigation required prior to further pigging operations.*

1.1.1.2. Bend Angle

The standard reporting threshold is every bend over 5 degrees. All bends are rounded to the nearest 5 degrees unless otherwise requested by Enbridge Energy, Limited Partnership.

Bends detected below 5 degrees may be left in the data for completeness, however their reporting is on a reasonable endeavours basis. These bends may be rounded down to an angle of 0 degrees.

1.1.2. IMU Specification

The IMU unit contains three accelerometers (Accel X, Y, Z) and three gyroscopes (Gyro X, Y, Z). These monitor acceleration and angular movement in space respectively, in three orthogonal axes (X, Y, Z).

The accelerometers and gyroscopes respond to the movement of the inspection vehicle and effectively trace the route of the vehicle as it travels down the pipeline.

The standard system accuracy is ±1.5 m (4.9 ft), with 90% confidence level, for all points along the route provided that the following conditions are satisfied;

(i) An above ground survey is conducted at the launch and receive and at sites every 3km (9840ft) along the pipeline. This survey provides artificial reference points in order to correct for any drift in the mapping data collected;

(ii) Satisfactory maglogger (above ground marker) trigger files have been obtained for all sites;

(iii) The vehicle velocity is steady and within the contractual velocity range throughout the inspection operation.

The location accuracy of girth weld coordinates is summarised below.

Marker Spacing	Location Accuracy (x, y, z)	Confidence
1km (3280ft)	±1.0m (3.3ft) - using Marker magnets	90%
3km (9840ft) or less	±1.5m (4.9ft) - using Above Ground Markers	90%
Greater than 3km (9840ft)	Marker spacing divided by 2000	90%

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Global Positioning System (GPS) co-ordinates are supplied in the WGS84 format for all identified girth welds and features, in accordance with the contract specification.

Pre and post run commissioning is carried out on the IMU unit to ensure its operation is satisfactory to meet the required contractual specification.

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1.2. Operational Information

The following information summarises the operational aspects of the survey.

1.2.1. Pipeline Operational Data

The following table summarises the pipeline data.

Pipeline Length	4.116 miles
Construction Date	1953
Predominant Pipe Type	Seamless
Predominant Pipe Specification	Grade A
Predominant Nominal Wall Thickness	0.812 in 0.500 in
Predominant External Coating	Coal Tar Enamel / Fusion Bonded Epoxy
Predominant Internal Coating	Not Supplied
Product	Crude Oil

1.2.2. Details of Personnel Involved in the Operation

The following personnel were involved in conducting the inspection survey:

Project Manager:	Tanis Lindberg
Field Crew Supervisor:	David Dempsey, Larry Montano
Data Analysis Lead Analyst:	Martin He
Data Analysis Report Approver:	John Ma

1.2.3. Vehicle Run Information

The following summarises the information from the current inspection:

Inspection Vehicle Type	Inspection Vehicle ID Number	Launch Date	Receive Date	Duration Hrs:Min
New MagneScan Geometry (Caliper)/IMU	GT/402000/0001	17 January 2020	17 January 2020	0:37

The tool was pulled from the pipeline on the 17th of January 2020.

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1.2.4. Vehicle Velocity Information

The velocity plot shows the speed of the inspection vehicle during the inspection run.

The red line on the velocity plot indicates the specified maximum velocity for the inspection vehicle, i.e. 16.40 ft/s. If the vehicle exceeds the specified maximum velocity then the performance of the inspection vehicle may be degraded.

The inspection vehicle did not exceed the specified maximum velocity during the inspection survey.

The inspection vehicle's average velocity during the inspection run was 9.8 ft/s.

The velocity profile plot is presented overleaf.

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VELOCITY PLOT

Line 05: 20" West North Straits to West Mackinaw (WNO-WMA)

Contractual Maximum and Minimum Velocities

451591_20B
Issue 1

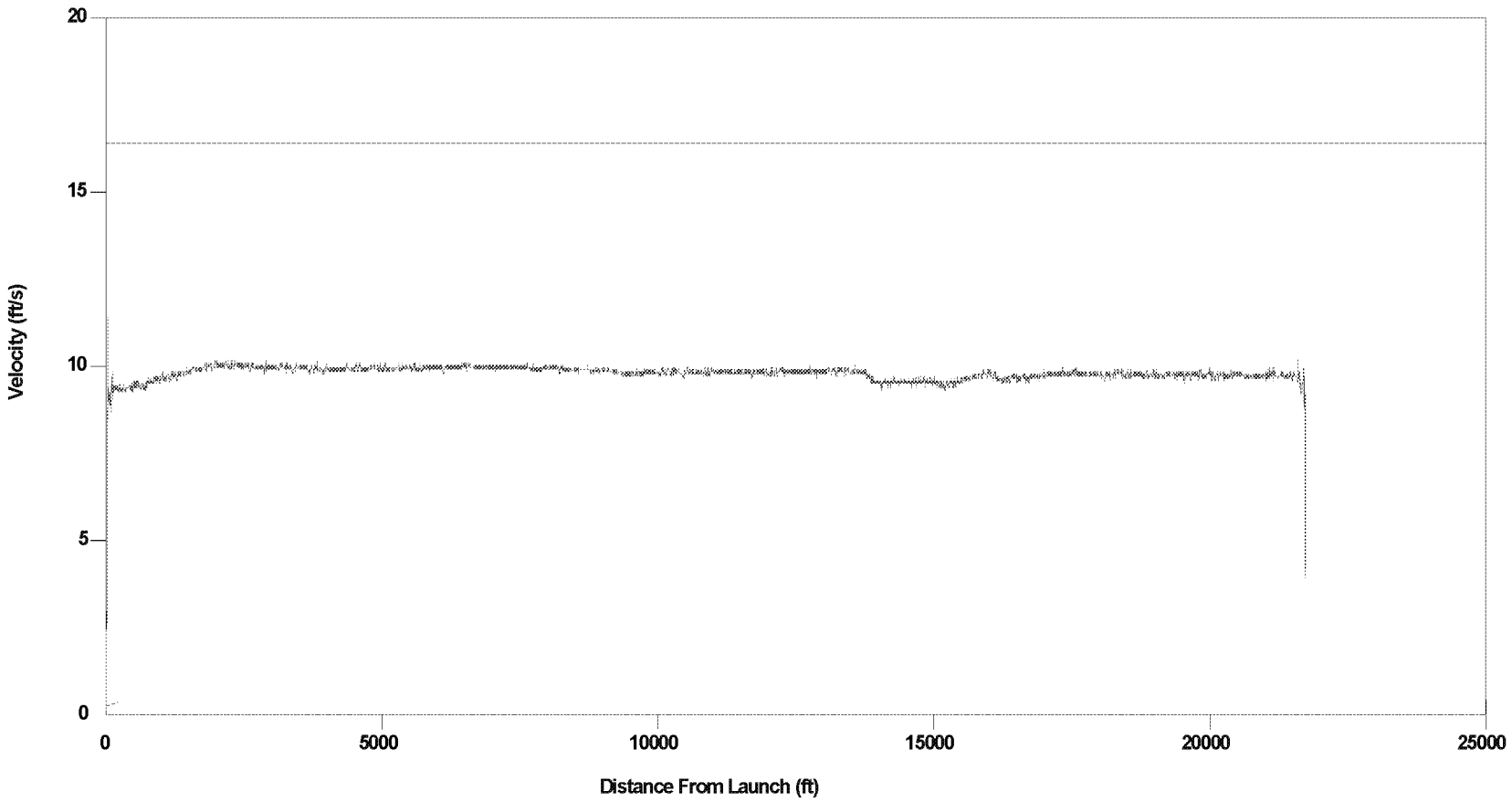


Figure 1 Velocity Plot

1.2.5. Data Quality

1.2.5.1. Geometry (Caliper) Data Quality

Inspection data was obtained for the full length (4.116 miles) of the pipeline.

We have detected 8 non-adjacent faulty caliper sensor channels throughout the run. Specifications were not affected by this issue and contractual specification have been met.

1.2.5.2. IMU Data Quality

1 marker spacing above specified limit of 1.86 miles has been detected in the original GPS Survey. As a result of this, specification has been reduced over this area.

Reference Point	Absolute Distance (ft)	Marker Spacing (ft)	Marker Spacing (miles)	Comments	Horizontal Specification (± ft)	Vertical Specification (± ft)
L05-NO(W)MA-0000	23.09	1034.48	0.20		4.92	4.92
L05-NO(W)MA-0010	1057.58	19697.38	3.73	Marker spacing	9.85	9.85
L05-NO(W)MA-0020	20754.96	956.03	0.18		4.92	4.92
L05-NO(W)MA-0030	21710.99				4.92	4.92

Apart from this, the quality of the inspection data is satisfactory and this has enabled a comprehensive assessment of the pipeline to be carried out

2. Pipeline Summary Reports

The Summary Reports provide an overview of the pipeline condition. The following summary reports are provided:

- Summary of Dents
- Summary of Other Geometric Features
- Minimum Detected Pipeline ID
- Summary of Strain
- Summary of Pipeline Changes

2.1. Summary of Dents

3 dents have been detected during this pipeline inspection.

The following tables summarise the dents detected during the pipeline inspection.

Dent Type	Top 8 through 12 to 4 o'clock (including 8 and 4 o'clock	Bottom 8 through 6 to 4 o'clock	Total
Plain Dents	2	1	3
With Girth Weld	0	0	0
Total	2	1	3

Table 1 Summary of Dents by Orientation

Dent Type	Depth <2.00%OD	2.00%OD≤ Depth <6.00%OD	Depth ≥6.00%OD	Total
Plain Dents	1	2	0	3
With Girth Weld	0	0	0	0
Total	1	2	0	3

Table 2 Summary of Dents by Depth

The deepest dent possesses a depth of 3.53% of the outside diameter (OD) and is located in pipe spool number 3540.

Details of the dents identified during the inspection survey are presented in the pipeline listing, and summarised in the table below.

Table 3 Summary of Geometry Feature Severity

Feature Type	Top	Bottom	Max Depth (%)
Geometry Feature Depth d ≥ 5%	0	0	3.53
Geometry Feature associated with stress risers or welds	0	0	N/A

The dent distribution plot displays the (centre) circumferential position of detected dents against the distance from launch, over the full pipeline length, and graded by selected dent depth categories. The dent distribution plot is presented overleaf.

The dent depth distribution histograms show the distribution of all detected dents along the pipeline, based on the selected dent depth categories. Each bar on the histogram represents the number of dents within a 50 ft section of the pipeline. The dent depth distribution histogram is presented after the dent distribution plots.

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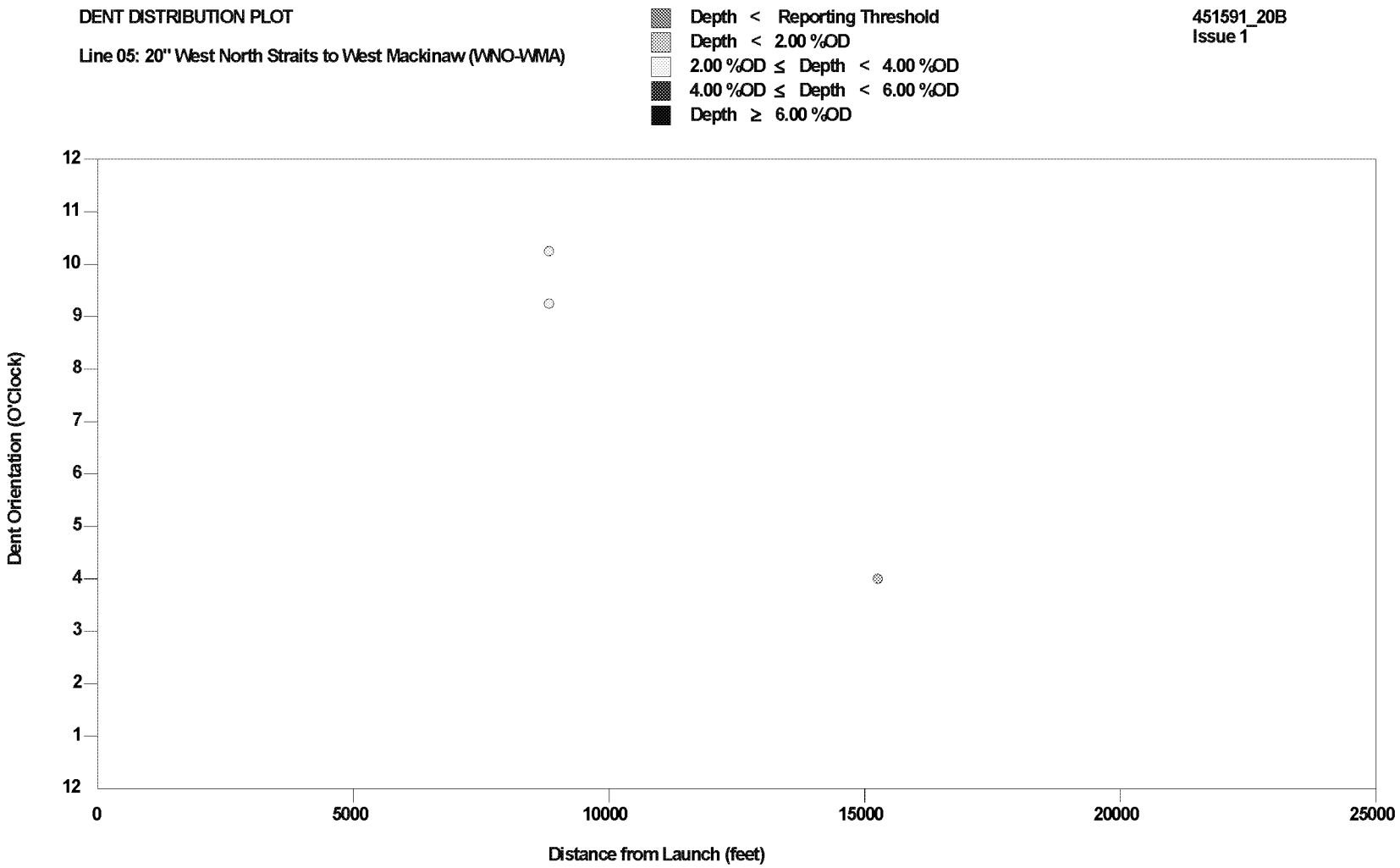


Figure 2 Distribution of dents around the pipeline circumference and along the pipeline length, according to depth

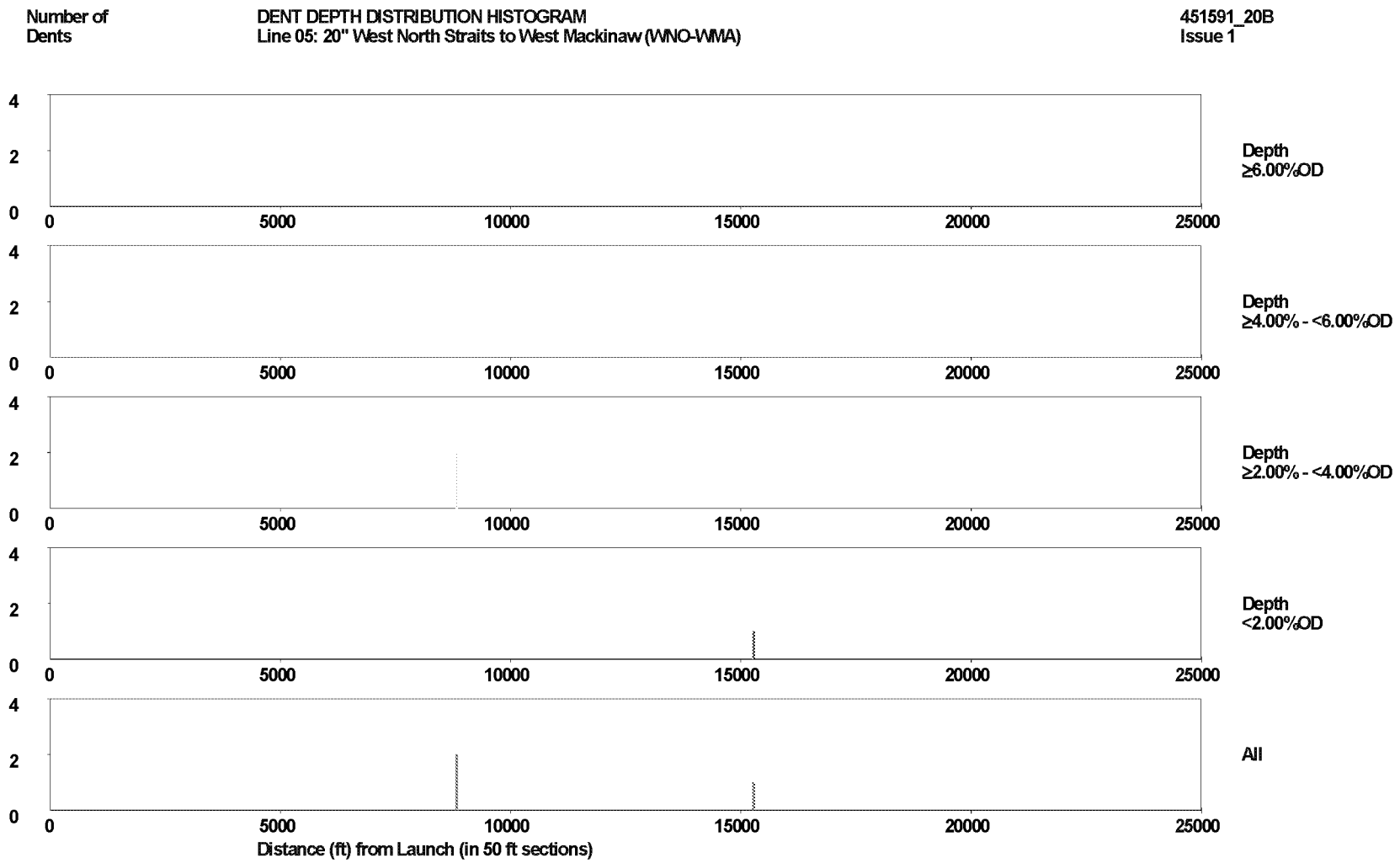


Figure 3 Distribution of dents along the pipeline length according to depth

2.2. Summary of Other Geometric Features

No other geometric features, such as Ovalities or ID Reductions,have been detected during the pipeline inspection.

No wrinkles or buckles have been detected during the pipeline inspection.

2.3. Minimum Detected Pipeline ID

The minimum detected ID on the pipeline is 17.499 in. This minimum ID is associated with a dent, located 12.014 feet downstream of girth weld 3540 at a distance of 8827.162 feet from launch.

2.4. Summary of Strain

The following tables summarise the strain and pipe movement detected during the pipeline inspection.

Table 4 Summary of Strain Severity

Feature Type	No. of Features	Largest Strain Difference Vertical %	Largest Strain Difference Horizontal %	Largest Strain Difference Total %	GW	Absolute Distance	Comments
Strain	NA	N/A	N/A	N/A	N/A	N/A	N/A
Worst Strain (excluding replacements & re-routes)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 5 Summary of Pipe Movement

Feature Type	No. of Features	Vertical Movement	Horizontal Movement	GW	Absolute Distance	Comments
Pipe Movement	N/A	N/A	N/A	N/A	N/A	N/A
Largest Movement (excluding replacements & re-routes)	N/A	N/A	N/A	N/A	N/A	N/A
	N/A	N/A	N/A	N/A	N/A	N/A

2.5. Summary of Pipeline Changes

This pipeline was previously inspected by Baker Hughes using MFL technology on the 14th of March 2019. The previous report reference number is 451199_20B.

The following table summarises and explains the differences in the numbers of the reported features between the current inspection and the previous inspection 451199_20B.

Feature Type	451199_20B - MFL - 14 March 2019	451591_20B - 17 January 2020	Comment
Dents	2	3	1 new dent has been reported.
Ovalities	0	0	No changes between inspections.
ID Reductions	0	0	No changes between inspections.
ID Expansions	0	0	No changes between inspections.

Table 6 Summary of Changes to the Number of Reported Features

3. Pipeline Listing

The pipeline listing presents the sequence of girth welds, pipeline fittings, dents, ovalities, internal diameter reductions, internal diameter expansions, and high girth welds detected along the pipeline. Location reference points and changes in the pipe wall thickness are also included in the pipeline listing.

The pipeline listing is presented electronically in an excel spreadsheet on the accompanying flash media storage, in the format specified by Enbridge and it follows the ILI Minimum Reporting Requirements Guide V.8.2.

Appendix A. Additional Information

This appendix contains appropriate, agreed, information to be supplied with the report. Typically this section includes the following:

- Appropriate information generated during the operational phase of the contract.

- Interim analysis information.

The information listed above is presented in the following sections.

A1. Operational Information

Contract Number	451591_20B
Operator	Enbridge Energy, Limited Partnership
Launch Site	West North Straits
Receive Site	West Mackinaw
Inspection Run	
Date of Operation	17 January 2020
Duration of Run	0 hours 37 minutes
Data Recorded	0 miles to 4.116 miles
Inspection Modules	MV: 59 IV: 1162 IMU: 430030
Project Manager	Tanis Lindberg
Sales Manager	Oscar Lozada
Analysis Regional Manager	Matias Giardino
Inspection Team Leader	Gerald Kong

A2. GPS Survey Point List

This section includes a complete list of all the GPS survey points measured in field and used in the present report for reference purposes.

GPS co-ordinates are listed below.

Site Reference	WGS-84		
	Latitude Degrees	Longitude Degrees	Elevation feet
AGM L05-NO(W)MA-0000	45.84127978	-84.75463147	586.785
AGM L05-NO(W)MA-0010	45.84022358	-84.75717966	580.217
AGM L05-NO(W)MA-0020	45.78783603	-84.77685605	599.298
AGM L05-NO(W)MA-0030	45.78629988	-84.77510601	651.434