INSPECTION INTELLIGENCE NDT GLOBAL

FINAL REPORT

Ultrasonic Crack Inspection

Evo 1.0 UCc

Enbridge Energy, Limited Partnership

4.10 mi. x 20" Line 5
North Straits East – Mackinaw

Run ID	ENBNM19U0	
Run date	06 Mar 2019	
Frame contract no.	MSA 23252	
NDT project no.	301024	
Version 1	04 July 2019	Initial release

NDT Global Inc.

6302-39 Street
Leduc, Alberta T9E 0Z3
Canada
+1 780 612 3100
www.ndt-global.com

Key Account Manager	Tom Machnik
Project Manager	Justin Han
Tool Operator	Matt Chichak
Data Analysis Project Leader	Achim Notheisen
Data Analysis Global Manager	Rogelio Guajardo

This report is expressly subject to the terms of the agreement governing the pipeline inspection that produced the data on which the report is based and to the below stated disclaimer.

This inspection report including any recommendations made by the contractor relating to the pipeline has been prepared by the contractor to his best knowledge and belief. All recommendations are made in good faith and are a reliable expert opinion of the contractor, according to common practice prevailing in the pipeline industry. The report or measures based on it will not constitute a warranty of the quality, capacity, safety or fitness for purpose of the pipeline.

Copyright © 2019, NDT Global, Version 1

Executive summary

Enbridge Energy contracted NDT Global to perform an ultrasonic circumferential crack detection survey for the 20" Line 5 from North Straits East to Mackinaw. The primary objectives of this survey were to detect, size, and locate axial cracks and crack-like features.

To achieve these objectives, NDT Global utilized a 20" Evo 1.0 inspection robot, recording a total of 4.13 mi. of data.

The quality of the recorded data fulfills the acceptance criteria for a successful run according to POF 2016.

The stated performance specifications can be achieved over the entire pipeline length and circumference.

The inspection run is classified as successful.

NDT Global's Data Analysts have analyzed the full data set. The major results can be summarized as follows:

1 **crack-like anomaly** is included in the listing.

The internal crack-like anomaly with ID 5926 has a calculated depth of 51 mil and is located at distance 5523.96 ft.. It has the comment "possible weld anomaly".

The following table gives an overview of the linear indication severity in the pipeline.

Feature type	Depth > saturation limit	Depth 0.08 in. to saturation limit
Crack-like	0	0
Crack field	0	0
Notch-like	0	0
Total	**0**	**0**

In addition, 2 **geometric anomalies** are included in the listing.

For clarification of any aspect of a survey, please contact our office.
NDT Global welcomes the opportunity to provide continued service to Enbridge Energy.

Copyright © 2019, NDT Global, Version 1

Contents

1 Operational details 6

1.1 Pipeline information 6
1.2 Medium information 6
1.3 Pipeline preparation 7
1.4 Inspection run details 7

2 Run profiles 8

2.1 Speed profile 8
2.2 Temperature profile 9
2.3 Pressure profile 10
2.4 Pendulum profile 11

3 Data quality 12

4 Results 13

4.1 Reporting criteria 13
4.2 Overview of the detected features 14
4.3 UCc graded anomalies 15
4.4 Geometric anomalies 16
4.5 Installations 16
4.6 Run comparison 17

5 Examples of features 19

6 Charts 22

6.1 Distribution of UCc graded anomalies 22
6.2 Distribution of geometric anomalies 23
6.3 Distribution of wall thickness 24

Copyright © 2019, NDT Global, Version 1

7 Overview of the appendix contents 25

8 Key to the listing 26

8.1 Generic attributes 26

8.2 Metal loss attributes 31

8.3 Crack attributes 33

8.4 Geometry attributes 34

8.5 Strain attributes 37

Copyright © 2019, NDT Global, Version 1

1 Operational details

1.1 Pipeline information

Pipeline name	Line 5
Launcher – receiver	North Straits East – Mackinaw
Construction year	1953
Commissioned length	4.10 mi.
Recorded length	4.13 mi.
Analyzed length	21718.86 ft.
Outer diameter	20"
Minimum bend radius	5D/90°
Wall thickness range	0.500 in. – 0.812 in., predominant: 0.812 in.
Weld type	Seamless
Steel grades	API 5L X30 API 5L X52 API 5L X60 API 5L X65

Table 1 – Information about the pipeline

1.2 Medium information

Product for normal operation	Light crude oil
Product for inspection survey	Light crude oil
Sound velocity in coupling medium	52.13 mil/µsec @ 50 °F
Attenuation in coupling medium	5 dB @ 50 °F
Temperature during inspection	Min. 37 °F Avg. 49 °F Max. 52 °F

Table 2 – Information about the medium

Copyright © 2019, NDT Global, Version 1

1.3 Pipeline preparation

No recent cleaning runs were performed in the pipeline.

1.4 Inspection run details

The following inspection was performed after validating the passage clearance:

Robot type & inspection technology	Evo 1.0 UCc
Run ID	ENBNM19U0
Insertion of the robot	06 Mar 2019, 08:35
Launch of the robot	06 Mar 2019, 09:15
Arrival of the robot	06 Mar 2019, 11:21
Retrieval of the robot	06 Mar 2019, 12:45
Speed of the robot[1]	Min. 1.13 mph Avg. 2.21 mph Max. 2.59 mph
Condition of the robot	No obvious malfunctions
Amount of debris	None

Table 3 – Inspection run

[1] Acceleration and deceleration are not considered for minimum and maximum values.

2 Run profiles

2.1 Speed profile

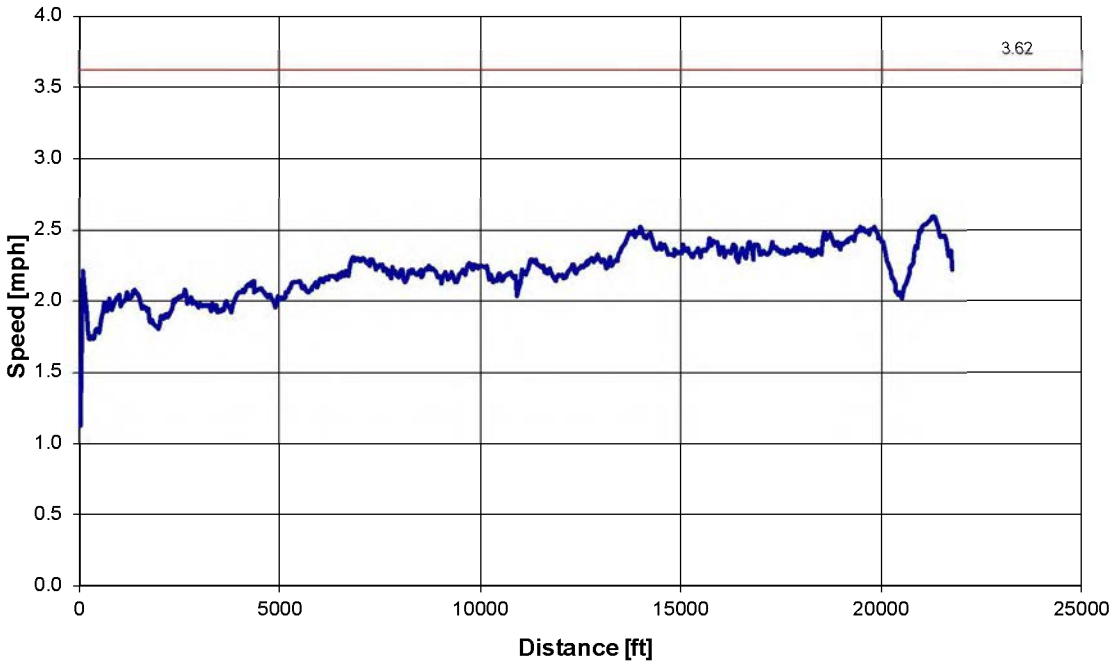


Figure 1 – Speed profile

The robot speed was below the specified maximum speed of 3.62 mph for the whole distance range, i.e. the robot performed within the scope of its specifications.

2.2 Temperature profile

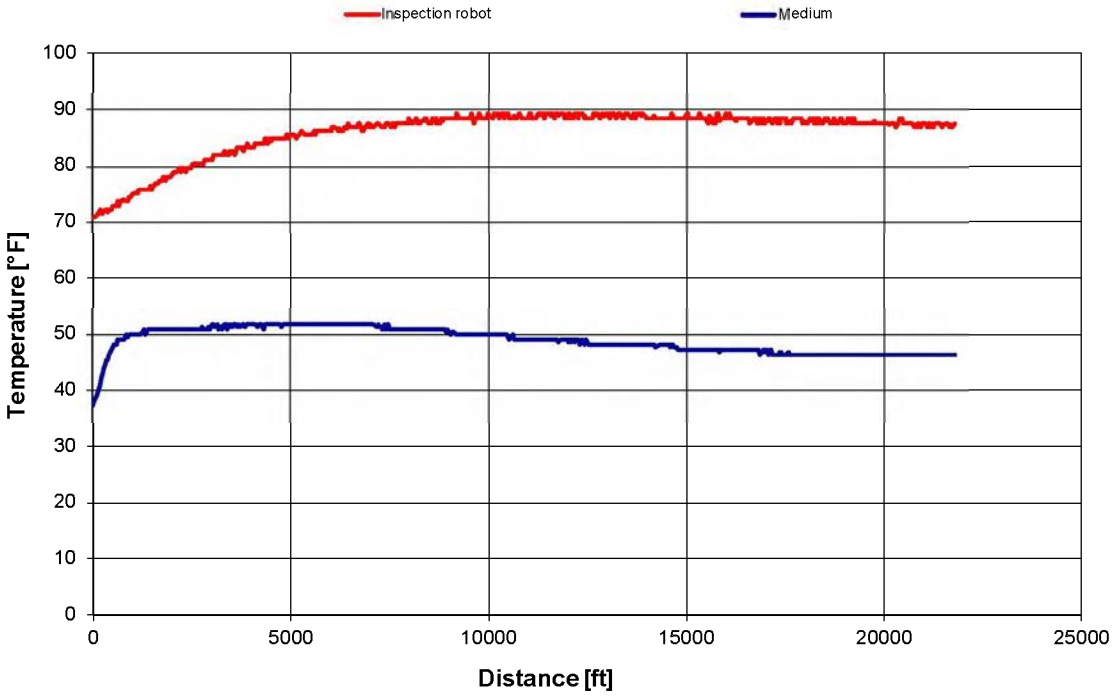


Figure 2 – Temperature profile

2.3 Pressure profile

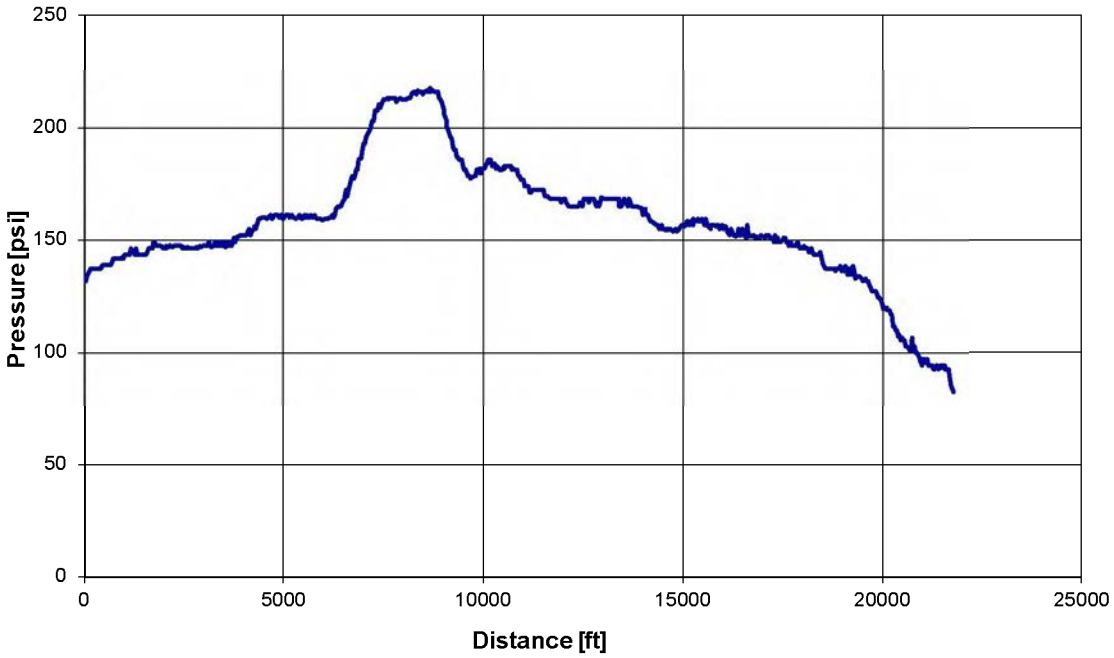


Figure 3 – Pressure profile

2.4 Pendulum profile

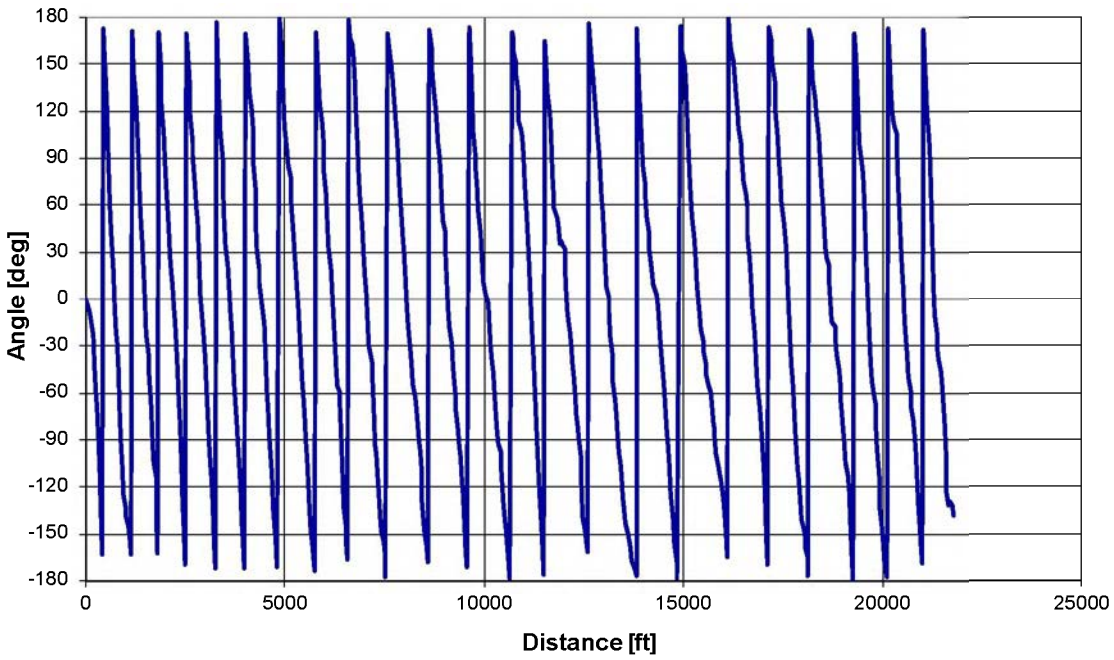


Figure 4 – Pendulum profile

The rotation of the robot does not affect data analysis because it is recorded by the pendulum and considered during data processing.

3 Data quality

Data was recorded by all channels, covering the entire circumference and length of the inspected distance.

The quality of the recorded data fulfills the acceptance criteria for a successful run according to POF 2016.

Based on the statistics and results of the data quality assessment it can be concluded that the quality of the recorded data is good, complete and has consistent amplitudes over the total inspection distance.

The total coupling loss is 0 % for the crack signals. There are no sensors with continuous coupling loss.

The stated performance specifications can be achieved over the entire pipeline length and circumference.

The inspection run is classified as successful.

The assessment of the data quality was reported to Enbridge Energy and the inspection data accepted for analysis.

Copyright © 2019, NDT Global, Version 1

4 Results

4.1 Reporting criteria

The following criteria were selected for final analysis.

UCc graded anomaly	Minimum depth Minimum length	0.04 in. 1.18 in.
Installation		All

Table 4 – Reporting criteria

All distances stated in this report and the listing are odometer distances.

Copyright © 2019, NDT Global, Version 1

4.2 Overview of the detected features

The following features are included in the listing:

Feature type	Description	Qty.
Crack-like anomaly	Crack-like anomaly in the weld seam, fatigue crack, etc.	1
Geometric anomaly		2
Installation		21
Total		**24**

Table 5 – Overview of the reported features

Linear indication severity of crack field, crack-like, and notch-like anomalies:

Feature type	Depth > saturation limit	Depth 0.08 in. to saturation limit
Crack-like	0	0
Crack field	0	0
Notch-like	0	0
Total	**0**	**0**

Table 6 – Linear indication (crack) severity

Copyright © 2019, NDT Global, Version 1

4.3 UCc graded anomalies

In UCc data analysis, it is sometimes difficult to distinguish crack-like or crack field anomalies from notch-like or metal loss anomalies. Therefore, these anomalies were, in a conservative way, classified as crack-like or crack field anomalies. However, it cannot be excluded that they are really manufacturing-related or metal loss anomalies. In this case, a corresponding comment is added in the listing.

1 **crack-like anomaly** is included in the listing.

The internal crack-like anomaly with ID 5926 (Figure 7) has a calculated depth of 51 mil and is located at distance 5523.96 ft.. It has the comment "possible weld anomaly".

Distribution of UCc graded anomalies according to their calculated depths:

Depth (mil)	Crack-like anomaly Qty.
< 39	0
39 – 78	1
≥ 79	0
Total	**1**

Table 7 – Distribution of UCc graded anomalies according to depth

Copyright © 2019, NDT Global, Version 1

4.4 Geometric anomalies

2 **geometric anomalies** are included in the listing.

The geometric anomaly with ID 8966 has the comment “verified: geometric anomaly with minor scrapes (<10 % NWT)”.

The corresponding diagrams in chapter 6.2 give an overview of the distribution of the geometric anomalies in the pipeline.

The following table gives an overview of the wrinkle/buckle severity:

Feature type	Top	Bottom	Max. depth %
Wrinkles/buckles	n/a	n/a	n/a
Wrinkles/buckles across seam welds or girth welds	n/a	n/a	n/a

Table 8 – Wrinkle/buckle severity

4.5 Installations

The following features were classified as installations:

Installation type	Qty.
Valve	2
Flange	1
T-piece	3
Offtake	13
Appurtenance other	2
Total	**21**

Table 9 – Overview of the pipeline installations

Copyright © 2019, NDT Global, Version 1

4.6 Run comparison

All features that were entered into the listings of 2018 and/or 2019 were reviewed and compared. The results are summarized below.

The explanation for the variations observed between 2014, 2017, 2018 and 2019 is that these features are “borderline features”. Borderline features have depth estimations around 39 mil. They could show a calculated depth ≥ 39 mil in one inspection and a calculated depth < 39 mil in another inspection. The differences in depth calculation are caused by the measurement tolerances from the tool and the geometry and dimensions of the feature. The same will apply for features with lengths that are considered borderline, this is around 1.18 in

4.6.1 Features reported in 2018 and in 2019

1 crack-like anomaly was entered into the 2019 listing and into the 2018 listing.

Crack-like anomaly with ID 5926 Run ID / Inspection year	Depth (mil)
ENBNA14U0	35
ENBNA17U0	24
ENBNA18U0	43
ENBNA19U0	51

Table 10 – Depth comparison of the feature reported in 2019 and in 2018

4.6.2 Features reported in 2019 only

No crack-like anomalies were entered into the 2019 listing but not into the 2018 listing.

Copyright © 2019, NDT Global, Version 1

4.6.3 Features reported in 2018 only

1 crack-like anomaly was entered into the 2018 listing but not into the 2019 listing.

Crack-like anomaly with ID 19367 Run ID / Inspection year	Depth (mil)
ENBNA14U0	24
ENBNA17U0	79
ENBNA18U0	63
ENBNA19U0	20

Table 11 – Depth comparison of the feature reported in 2018 but not in 2019

In all data sets, the anomaly shows a circumferential length < 1.18 in. and therefore has dimensions outside the UCc feature specification. It was only detected by sensors in 1 or 2 tracks.

Copyright © 2019, NDT Global, Version 1

5 Examples of features

The following screenshots of the LineExplorer visualization software explain the major information provided by the C-scan and B-scans. In the C-scan screenshots, features are indicated by a red box.
All distances stated are odometer distances.

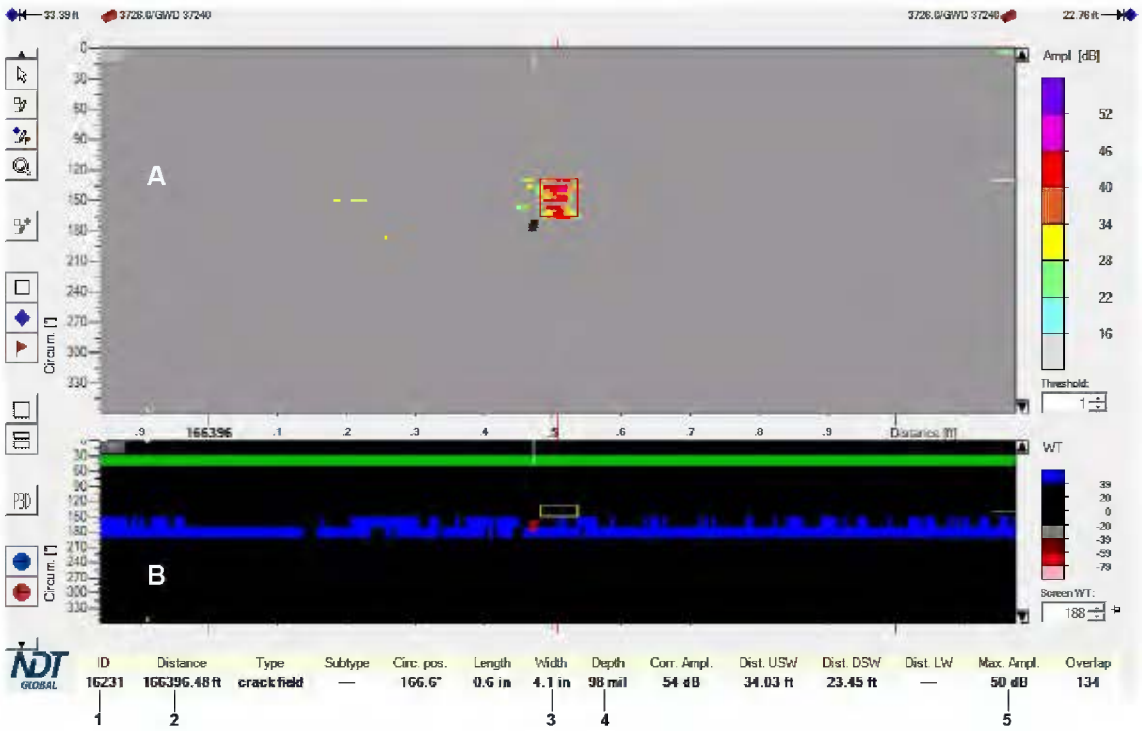


Figure 5 – Information provided in the C-scan demo screenshot

Item	Meaning	Item	Meaning
A	Crack detection C-scan display	1	Feature ID
B	Wall thickness C-scan display	2	Absolute distance of the feature
		3	Circumferential length of the feature
		4	Calculated depth of the feature
		5	Maximum amplitude of the feature

Copyright © 2019, NDT Global, Version 1

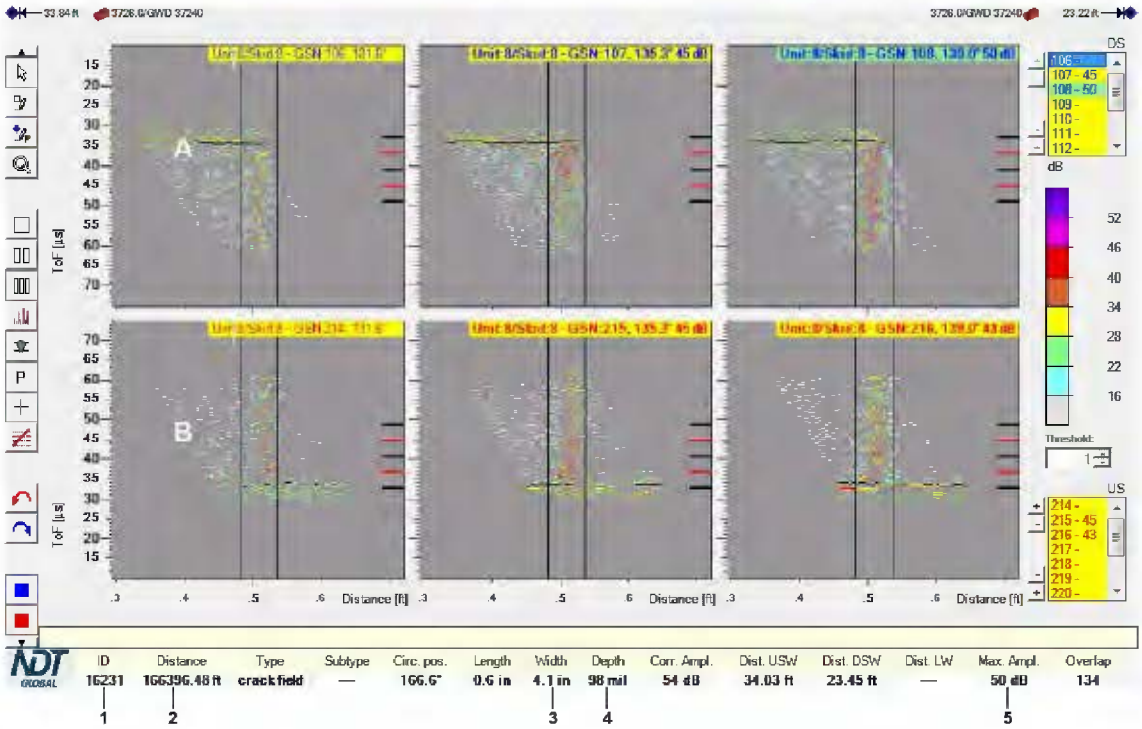


Figure 6 – Information provided in the B-scan demo screenshot

Item	Meaning	Item	Meaning
A	B-scan display of 3 neighboring sensors (downstream sensors)	1	Feature ID
B	B-scan display of 3 neighboring sensors (upstream sensors)	2	Absolute distance of the feature
		3	Circumferential length of the feature
		4	Calculated depth of the feature
		5	Maximum amplitude of the feature

Figure 7 shows the C-scan and B-scans of the internal crack-like anomaly with ID 5926. It has a calculated depth of 51 mil, is located at distance 5523.96 ft. and has the comment “possible weld anomaly”.

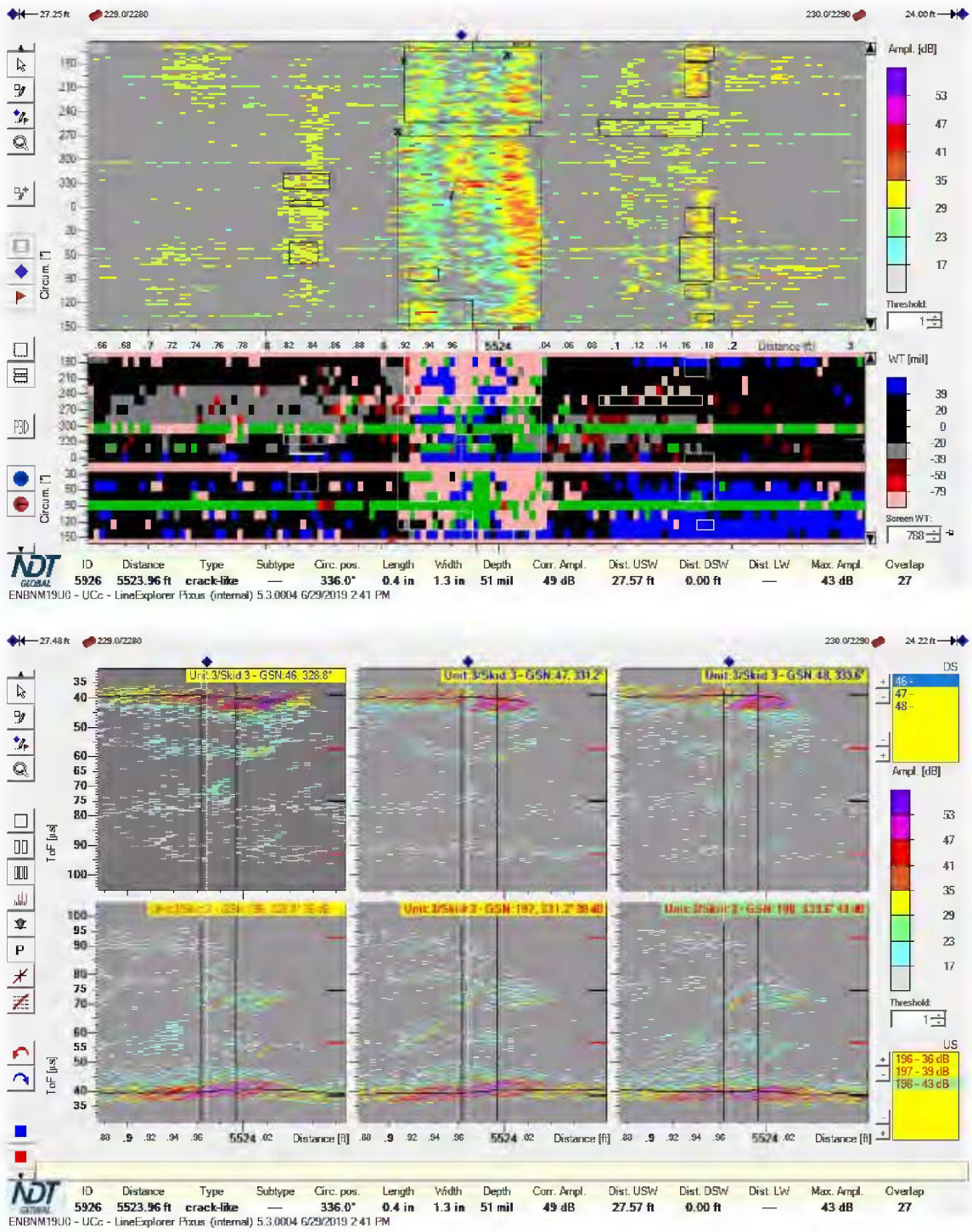


Figure 7 – Top: C-scan, bottom: B-scans of a crack-like anomaly (ID 5926)

6 Charts

6.1 Distribution of UCc graded anomalies

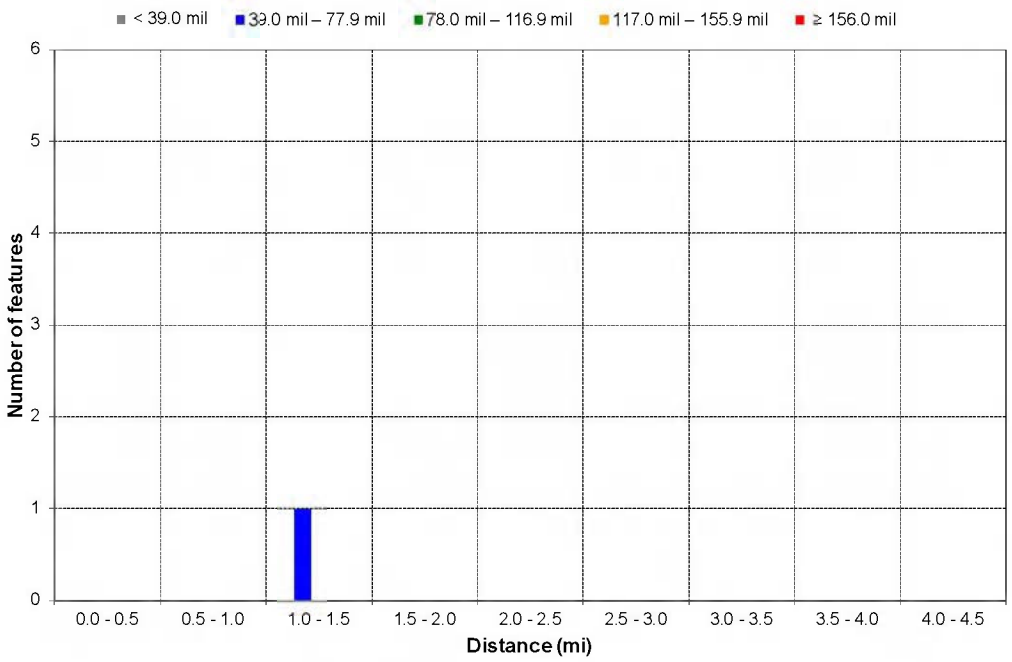


Figure 8 – Distribution of crack-like anomalies according to depth – number vs. distance

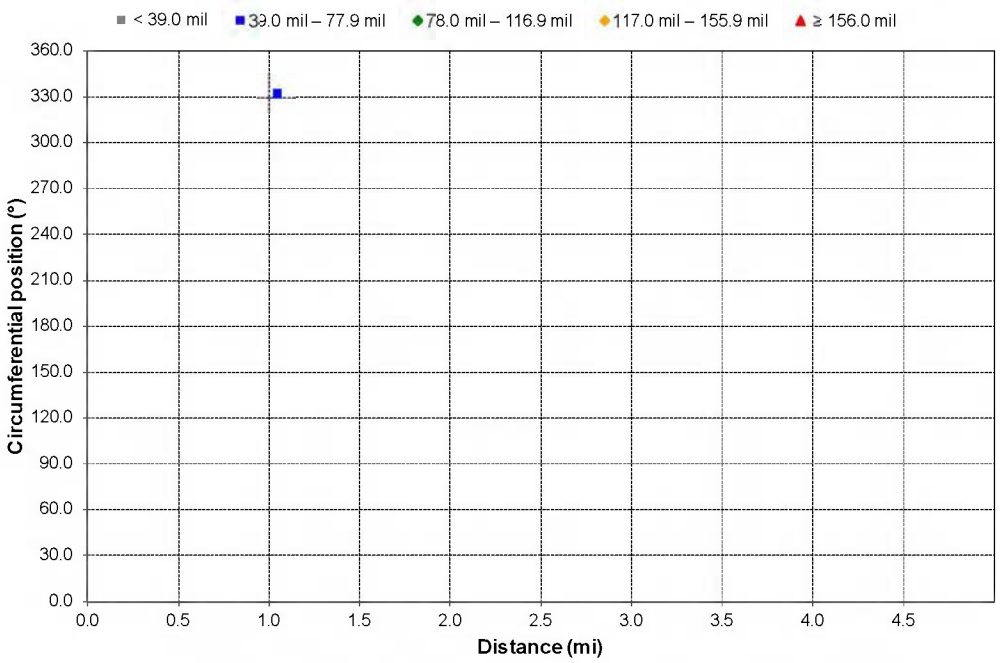


Figure 9 – Circumferential distribution of crack-like anomalies according to depth

Copyright © 2019, NDT Global, Version 1

6.2 Distribution of geometric anomalies

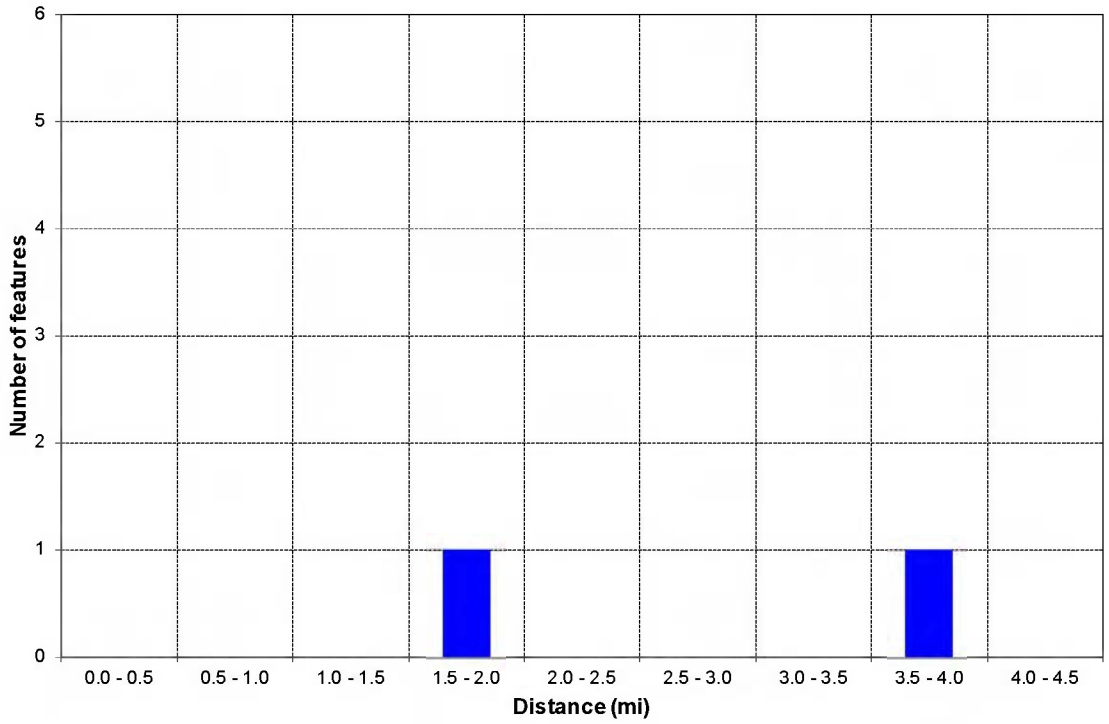


Figure 10 – Distribution of geometric anomalies – number vs. distance

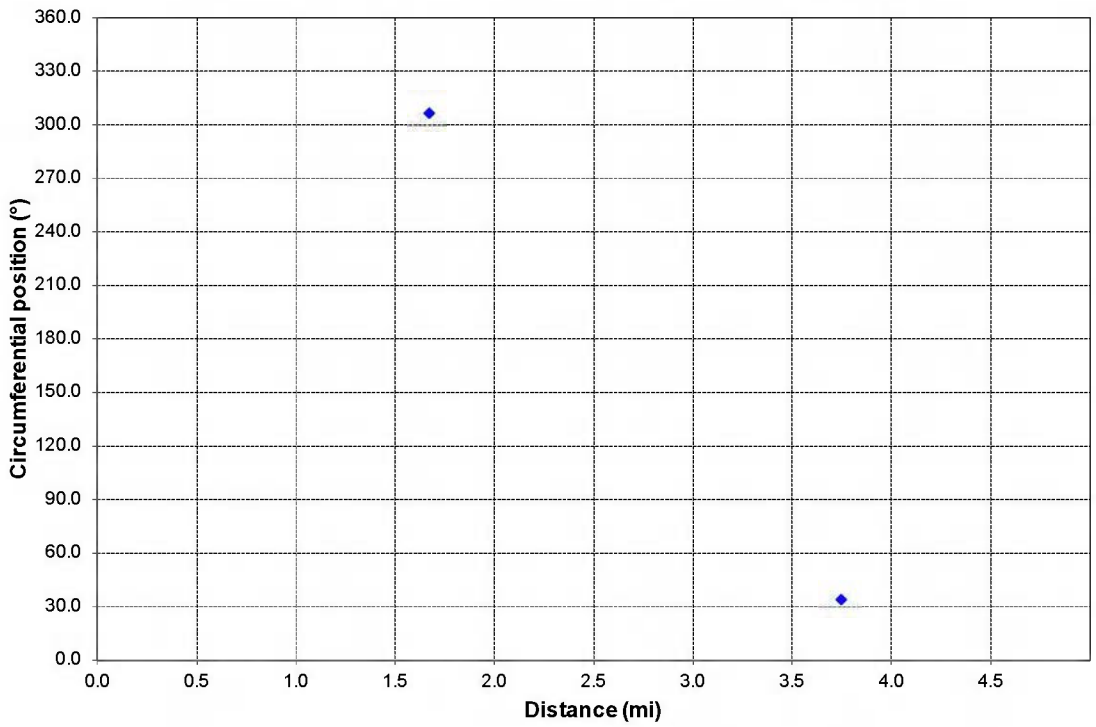


Figure 11 – Circumferential distribution of geometric anomalies

6.3 Distribution of wall thickness

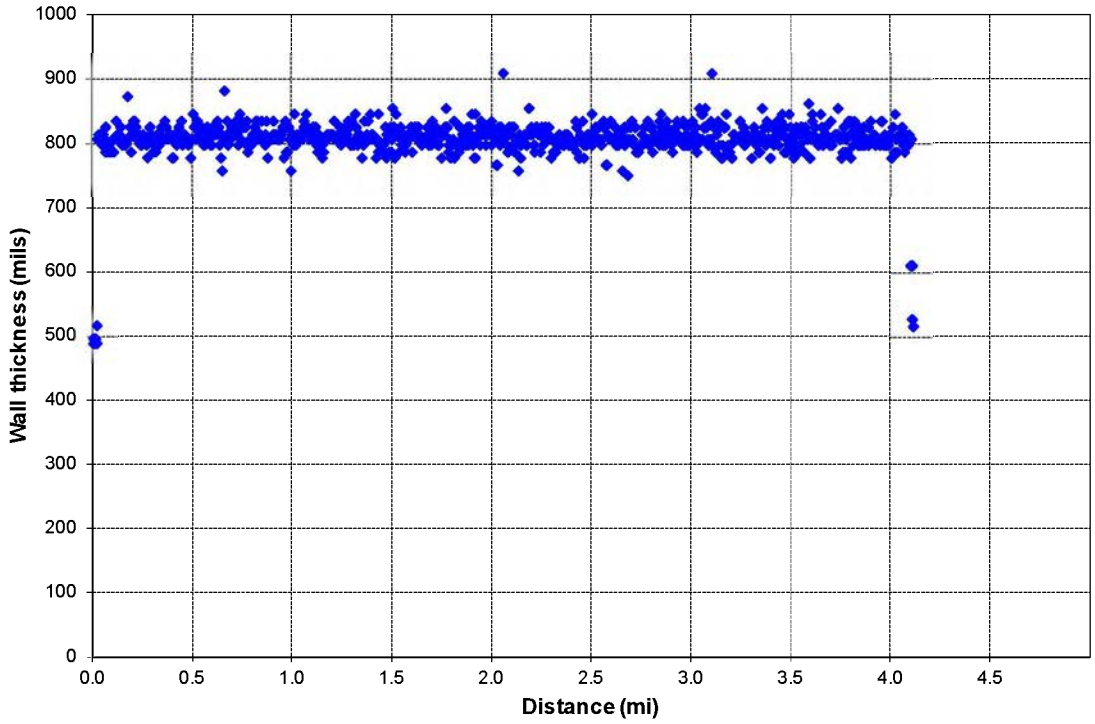


Figure 12 – Wall thickness distribution of the pipe joints

Copyright © 2019, NDT Global, Version 1

7 Overview of the appendix contents

The following documents are included in the appendix folder *ENBNM19U0-Appendix-en_Version1*:

Name	Description
Listing	Detailed inspection result lists.
Information about the inspection robot	**ENBNM19U0_TechnicalData** Overview of the configuration of the applied robot. **ENBNM19U0_RobotCertificate** Certification of robot preparation in accordance with NDT Global's process description *PD-008-SE-GLB "Preparation of Inspection Tools"* and in compliance with *POF 2016 Standard*[1] and American Petroleum Institute Standard *API 1163*[2].
Performance specification	Overview of the performance specification used for the inspection run: Crack detection: PS-013 Revision 7.0
ILI PQ certificates	Personnel certifications according to the *ILI PQ Personnel Qualification* standard.

Table 12 – Overview of documents included in the appendix folder

[1] POF 2016: "Specifications and requirements for in-line inspection of pipelines", Pipeline Operators Forum, version 2016.
[2] API 1163: "In-line Inspection Systems Qualification", second edition, April 2013.

Copyright © 2019, NDT Global, Version 1

8 Key to the listing

For the listing itself, please refer to the spreadsheet in the corresponding Excel file.

The listing consists of the following columns:

8.1 Generic attributes

Upstream girth weld	Upstream girth weld of the joint containing the start of the feature. For geometry features: the upstream girth weld of the joint containing the MSP of the feature.
Absolute distance (ft.)	Distance of the beginning of the feature to the reference distance 0 ft., based on the odometer reading.
Joint length (ft.)	Length of the pipe joint, measured from the middle of the girth weld to the middle of the girth weld.
Nominal pipe size (in.)	Diameter of pipeline, as provided by Enbridge Pipelines
Nominal wall thickness (ft.)	Nominal wall thickness of the joint, as provided by Enbridge Pipelines.
Actual measured local wall thickness (in.)	Local wall thickness measured in the vicinity of the feature by NDT Global's inspection tool. For UCc not available.
Average wall thickness (in.)	The most frequently measured wall thickness in a pipe joint.
Seam weld type detected	Type of seam weld used to fabricate the joint. **Note:** This is not the weld type used to attach 2 separate joints. ERW/FW electric resistance weld or flash weld. SAW submerged arc weld. DSAW double submerged arc weld. SPIRAL spiral weld. SMLS seamless weld. UNKN weld type could not be determined.

Copyright © 2019, NDT Global, Version 1

Seam weld orientation start detected (°)	Circumferential orientation of the seam weld at the US girth weld (clockwise from top looking downstream), as detected by NDT Global's inspection tool. For UCc not available.
Seam weld orientation end detected (°)	Circumferential orientation of the seam weld at the DS girth weld (clockwise from top looking downstream), as detected by NDT Global's inspection tool. For UCc not available.
Seam weld orientation start provided (°)	Circumferential orientation of the seam weld at the US girth weld (clockwise from top looking downstream), as provided by Enbridge Pipelines.
Seam weld orientation end provided (°)	Circumferential orientation of the seam weld at the DS girth weld (clockwise from top looking downstream), as provided by Enbridge Pipelines.
Pipe grade provided	Pipe grade, as provided by Enbridge Pipelines.
Joint insulated	Identifies whether or not the joint containing is electrically insulated.
Feature ID	Unique feature identifier, as provided by NDT Global.
Sleeve/Casing ID	Unique identifier of a sleeve or casing
Feature type	Possible feature types are: • crack-like • crack field (group of several crack-like features, e.g. SCC = stress corrosion cracking) • notch-like (gouging, scratches, etc.) • metal loss (general corrosion, pitting, channeling, etc.) • manufacturing-related (lamination, inclusion, blister, etc.) • dent • geometry (dent, ovality, wrinkle, bend, internal diameter reduction, etc.) • casing eccentric (area where casing is touching the pipe) • casing start / casing end • sleeve start / sleeve end • installation (flange, T-piece, valve, offtake, etc.)
Feature comment	• Additional information on the feature, if necessary.
Relative distance start (ft.)	Start distance of the feature from the US girth weld.
Relative distance end (ft.)	End distance of the feature from the US girth weld.

Copyright © 2019, NDT Global, Version 1

Relative distance centre (ft.)	Distance of the feature box from the US girth weld. This attribute only applies to geometric anomalies detected by technologies other than a caliper.
MSP relative distance (ft.)	Distance of the feature's most severe point (MSP) from the US girth weld.
Orientation start (°)	Circumferential position of the leading edge of the feature (clockwise from top looking downstream).
Orientation end (°)	Circumferential position of the trailing edge of the feature (clockwise from top looking downstream).
Orientation centre (°)	Circumferential position of the centre of the feature box (clockwise from top looking downstream). This attribute only applies to geometric anomalies detected by technologies other than a caliper.
MSP orientation (°)	Circumferential position of the feature's most severe point (clockwise from top looking downstream).
Length (in.)	Axial length of the feature box. For UCc technologies only: For the feature types crack-like, crack field, and notch-like anomalies, this corresponds to the anomaly width.
Width (in.)	Circumferential width of the feature box. For UCc technologies only: For the feature types crack-like, crack field, and notch-like anomalies, this corresponds to the anomaly length.
Depth (in.)	Maximum depth of the feature
Depth percent nominal	Depth of feature in percent of nominal wall thickness.
Depth percent local	Depth of feature in percent of local wall thickness.
Radial position	Radial position of the feature: Internal Feature was detected on the internal surface only. External Feature was detected on the external surface only. Internal and External: One or several features were detected on both the internal and external surfaces at the same location. Mid-wall Feature was detected within the pipe wall. Not decidable Position of the feature could not reliably determined.

Copyright © 2019, NDT Global, Version 1

Relative position to girth weld	Across girth weld	Feature is across the girth weld.
	For UM technologies only:	
	Adjacent to weld	Feature is within 25 mm from the centreline of the girth weld.
	In weld	Feature is within girth weld.
	Not associated	Feature is more than 25 mm from the centreline of the girth weld.
	For UC technologies only:	
	Adjacent to weld	Feature is between 50 mm and 400 mm from the centreline of the girth weld.
	In weld	Feature is within 50 mm from the centreline of the girth weld.
	Not associated	Feature is more than 400 mm from the centreline of the girth weld.
Relative position to seam weld	Across seam weld	Feature is across the seam weld.
	In weld	Feature is within seam weld.
	Not decidable	Unable to determine the relative position of the feature to the seam weld.
	For UM technologies only:	
	Adjacent to weld	Feature is within 25 mm from the centreline of the seam weld.
	For UC technologies only:	
	Adjacent to weld	Feature is within 20 mm from the centreline of the seam weld.
	Base metal	Feature is more than 20 mm from the centreline of the seam weld.
Bulging	Indicates whether or not a lamination has caused an extreme bulge.	
Intermittent	Indicates whether or not a lamination is non continuous.	
Sloping	Indicates whether or not a continuous lamination slopes as it approaches both the inner and outer surfaces.	
Surface breaking	Indicates whether or not a lamination extends to either the internal or external surface of the pipe.	
Variable depth	Indicates whether or not there are multiple laminations that vary in depth.	
IMU reported latitude (°)	IMU reported latitude of the feature.	
IMU reported longitude (°)	IMU reported longitude of the feature.	

Copyright © 2019, NDT Global, Version 1

IMU reported elevation (m)	IMU reported elevation of the feature.
Under sleeve	Indicates whether the feature is fully covered by a sleeve, or not.
Degraded data	Y Signal loss or degraded data due to overspeed, sensor failure, debris, coupling loss, electronic failure, etc. N No signal loss or degraded data.
Interacting with deformation	Feature is interacting with a deformation (Y), or not (N).
Interacting with crack	Feature is interacting with a crack (Y), or not (N).
Interacting with metal loss	Feature is interacting with a metal loss (Y), or not (N).
Interacting with manufacturing defects	Feature is interacting with a manufacturing-related defect (Y), or not (N).
Length accuracy (in.)	Tool resolution for the detection of the feature.
Depth accuracy (in.)	Tool accuracy for the detection of the feature.

Table 13 – Generic attributes

Copyright © 2019, NDT Global, Version 1

8.2 Metal loss attributes

Feature morphology	The dimensional classes as defined by API 1163.
Depth UTWM WT (in.)	Maximum depth of the feature based on UTWM WT.
Depth percent UTWM WT	Maximum depth of the feature based on Nominal WT.
Effective length (in.)	Effective axial length of the feature determined using the RSTRENG method.
Effective length nominal WT (in.)	Effective axial length of the feature determined using the RSTRENG method based on Nominal WT.
Effective length UTWM WT (in.)	Effective axial length of the feature determined using the RSTRENG method based on UTWM WT.
Effective depth (in.)	Effective depth of the feature determined using the RSTRENG method.
Effective depth nominal WT (in.)	Effective depth of the feature determined using the RSTRENG method based on Nominal WT.
Effective depth UTWM WT (in.)	Effective depth of the feature determined using the RSTRENG method based on UTWM WT.
Effective Area Failure Pressure (psi)	Calculated failure pressure of a metal loss feature using the effective area method.
Effective Area Failure Pressure Nominal WT (psi)	Calculated failure pressure of a metal loss feature using the effective area method based on Nominal WT.
Effective Area Failure Pressure UTWM WT (psi)	Calculated failure pressure of a metal loss feature using the effective area method based on UTWM WT.
MB31G Failure Pressure UTWM WT (psi)	Calculated failure pressure of a metal loss feature using Modified B31G
Effective Area RPR	Rupture Pressure Ratio (RPR) of the feature using the RTSTRENG method and river bottom profile.
Effective Area RPR Nominal WT	Rupture pressure ratio of the feature, calculated using the RSTRENG method, through assessment of river bottom profile based on Nominal WT.

Copyright © 2019, NDT Global, Version 1

Effective Area RPR UTWM WT	Rupture pressure ratio of the feature, calculated using the RSTRENG method, through assessment of river bottom profile based on UTWM WT.
MB31G RPR	Rupture Pressure Ratio (RPR) of the feature using Modified B31G.
Interacting with close metal loss	Indicates whether or not a metal loss feature is within 15.24 m (50 feet) of a detected metal object.
Proximity	Indicates if a detected ferrous metal object or casing is close to or touching the pipeline, based upon the magnetic signal.
Echo loss	Echo occurred at feature (Y), or not (N).
Echo loss rules	Rule type which triggered the echo loss flag during analysis.
Remaining wall thickness (in.)	Remaining wall thickness at most severe point of the feature (local wall thickness minus feature depth).

Table 14 – Metal loss attributes

Copyright © 2019, NDT Global, Version 1

8.3 Crack attributes

Longest interacting length (in.)	The longest length of linked cracks in a crack field (or the longest crack indication if there are no interacting indications); For UCc not available.
Depth range lower bound (in.)	Lower bound of the estimated crack depth range of the feature.
Depth range upper bound (in.)	Upper bound of the estimated crack depth range of the feature.
Single crack	The crack-like feature is a single crack (Y) or intermittent cracks (N).
Sensor lift off	The ability to detect, identify, or size the feature was reduced by a prominent girth weld root (Y), or not (N).
CW sensors	Number of clockwise sensors detecting a signal from the crack feature. For UCc, this corresponds to the number of downstream sensors.
CCW sensors	Number of counter-clockwise sensors detecting a signal from the crack feature. For UCc, this corresponds to the number of upstream sensors.
Width accuracy (in.)	Tool resolution for the detection of the feature.
Minimum detected length (in.)	Minimum feature length detectable by the robot. For UCc, this corresponds to the circumferential length of a feature.
Tool velocity (ft./s)	Velocity of the robot when passing the feature.
Name of previous inspection	Run ID of the previous run.
Previous inspection feature type	Feature type at this location reported in the previous report.
Previous inspection depth range lower bound (in.)	Lower bound of the estimated crack depth range of the feature in the previous report.
Previous inspection depth range upper bound (in.)	Upper bound of the estimated crack depth range of the feature in the previous report.

Table 15 – Crack attributes

Copyright © 2019, NDT Global, Version 1

8.4 Geometry attributes

Dent depth B (in.)	Depth of dent-like geometry feature, including the effects of pipe ovality.
Depth percent dent	Depth of geometry feature at the MSP, excluding the effects of pipe ovality.
Depth percent B	Depth of geometry feature at the MSP, including the effects of pipe ovality.
Ovality	Out-of-roundness relative to the nominal circular shape of the pipe.
US_LAX00 (in.)	The US axial distance from the MSP of the geometry feature to the point of 0 % of the peak depth.
US_LAX05 (in.)	The US axial distance from the MSP of the geometry feature to the point of 5 % of the peak depth.
US_LAX50 (in.)	The US axial distance from the MSP of the geometry feature to the point of the 50 % peak depth.
DS_LAX00 (in.)	The DS axial distance from the MSP of the geometry feature to the point of 0 % of the peak depth.
DS_LAX05 (in.)	The DS axial distance from the MSP of the geometry feature to the point of 5 % of the peak depth.
DS_LAX50 (in.)	The DS axial distance from the MSP of the geometry feature to the point of the 50 % peak depth.
CW_LTR00 (in.)	The clockwise transverse distance from the MSP of the geometry feature to the point of 0 % of the peak depth.
CW_LTR05 (in.)	The clockwise transverse distance from the MSP of the geometry feature to the point of 5 % of the peak depth.
CW_LTR50 (in.)	The clockwise transverse distance from the MSP of the geometry feature to the point of the 50 % peak depth.
CW_LTR00 (in.)	The clockwise transverse distance from the MSP of the geometry feature to the point of 0 % of the peak depth.
CW_LTR05 (in.)	The clockwise transverse distance from the MSP of the geometry feature to the point of 5 % of the peak depth.
CW_LTR50 (in.)	The clockwise transverse distance from the MSP of the geometry feature to the point of the 50 % peak depth.

Copyright © 2019, NDT Global, Version 1

Minimum distance of MSP to GW (in.)	The minimum distance of the geometry feature's MSP to the nearest girth weld.
Minimum distance of MSP to LSW (in.)	The minimum distance of the geometry feature's MSP to the nearest seam weld.
Internal pipe pressure at deformation (psi)	The internal pipe pressure at the location of the geometry feature.
Nominal ID (in.)	The nominal measured inner diameter of the joint containing the feature.
Minimum ID (in.)	The minimum measured inner diameter of the pipe at the location of the MSP.
Maximum ID (in.)	The maximum measured inner diameter of the pipe at the location of the MSP.
Associated with girth weld	The geometry feature is located at a girth weld (Y), or not (N).
Associated with seam weld	The geometry feature is located at a seam weld (Y), or not (N).
Topside	Y The MSP of the feature is on the topside, between 240° and 120°. N The MSP of the feature is on the bottom side, between 120° and 240°.
Off axis	The longitudinal axis of the dent is more than 15° from the longitudinal axis of the pipeline (Y), or equal or less than 15° (N).
MultiApex dent	The dent has more than one apex point (Y), or not (N).
Dent in close proximity	Y One or more topside dent MSPs (or feature box centres) are within 3 m (10 ft.) in axial direction and 60° in circumferential direction. Y Two or more bottom side MSPs (or feature box centres) are within 1.5 m (5ft.) in axial direction and 60° in circumferential direction. N None of the above conditions applies.

Copyright © 2019, NDT Global, Version 1

Bend angle (°)	Maximum angle of the bend.
Bend azimuth angle (°)	The angle of the direction change, looking down onto the pipeline.
Bend azimuth change direction	The bend moves right (Right) or left (Left), looking down onto the pipeline.
Bend pitch angle (°)	The angle of the tilt change.
Bend pitch direction	The bend moves up (Up) or down (Down).
Bend radius (OD)	Minimum radius of the curvature of the bend, on the plane of the bend angle.

Table 16 – Geometry attributes

Copyright © 2019, NDT Global, Version 1

8.5 Strain attributes

Strain value at largest difference horizontal	The horizontal component of the absolute bending strain at the peak total differential bending strain location.
Strain value at largest difference vertical	The vertical component of the absolute bending strain at the peak total differential bending strain location.
Strain value at largest difference total	The combined vertical and horizontal component of the absolute bending strain at the peak total differential bending strain location.
Largest strain difference horizontal	The horizontal component of the total differential bending strain between the current and the baseline inspection.
Largest strain difference vertical	The vertical component of the total differential bending strain between the current and the baseline inspection.
Largest strain difference total	The combined vertical and horizontal component of the total differential bending strain between the current and the baseline inspection.
Pipeline movement direction horizontal	The direction of the maximum horizontal location difference between the current and baseline inspections within the start and end of the chainage range.
Pipeline movement direction vertical	The direction of the maximum vertical location difference between the current and baseline inspections within the start and end of the chainage range.
Pipeline movement horizontal (ft.)	The maximum horizontal difference between the current and the baseline inspection within the start and end chainage range.
Pipeline movement vertical (ft.)	The maximum vertical difference between the current and the baseline inspection within the start and end chainage range.

Table 17 – Strain attributes

Copyright © 2019, NDT Global, Version 1

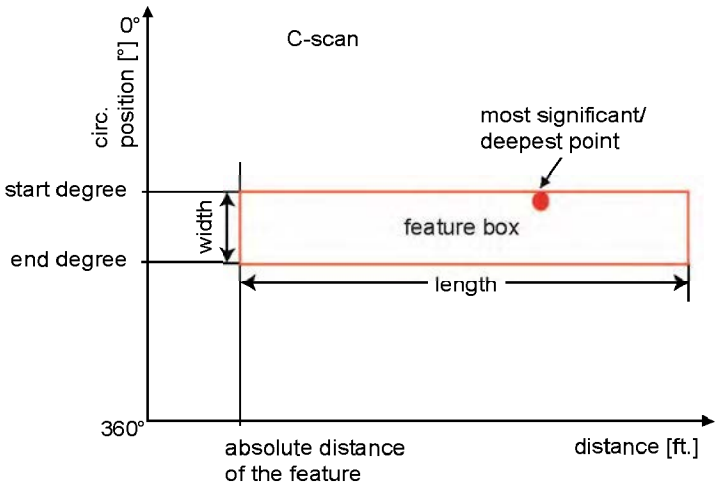


Figure 13 – Illustration of box coordinates

A feature is described by a surrounding rectangular box. In the C-scan representation, the absolute distance of the feature refers to the upstream border of the feature box and the circumferential start and end positions of the feature refer to the upper and lower borders of the feature box, respectively. 0° is at the top. The angular degree increases in clockwise direction when looking downstream.

Note: The width and length sizing in the performance specifications refer to the actual dimensions of the anomaly which may deviate from the width and length of the feature box, e.g. in the case of a diagonally oriented anomaly.

Copyright © 2019, NDT Global, Version 1