Specifications and requirements for intelligent pig inspection of pipelines

Version 3.2, January 2005

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1. Introduction

This document specifies the advised operational and reporting requirements for tools to be used for geometric measurement, pipeline routing, metal loss, crack or other defect detection during their passage through steel pipelines. The tools may pass through the pipeline driven by the flow of fluid or may be towed by a vehicle or cable. The tools may be automatic and self-contained or may be operated from outside the pipeline via a data and power link.

The document has been reviewed and agreed by the members of the Pipeline Operator Forum (POF) who are listed in Appendix 1. It is stated that neither the members of the Pipeline Operator Forum nor the Companies they represent can be hold responsible for the fitness for purpose, completeness and accuracy of this document.

A draft version of this document has been sent for comments to Intelligent Pigging Contractors as listed in Appendix 2. The members of the POF like to thank the contractors for their constructive feedback.

It is the intention to review the document in 2008. POF members and other users of this specification are free to add or change requirements based on their specific pipeline situation.

2. Standardisation

2.1 Definitions

Anomaly:	An indication, generated by non-destructive examination of an irregularity or deviation from base pipe or sound weld material, which may or may not be an actual flaw.
Arc strike:	Localised points of surface melting caused by an electrical arc (also referred to as hot spot).
Buckle:	A partial collapse of the pipe due to excessive bending or compression associated with soil instability, land slides, washouts, frost heaves, earthquakes, etc
Casing:	A type of feature consisting of a large diameter pipe placed concentrically around the pipeline, usually in high stress areas such as road crossings,
Cluster:	Two or more adjacent metal loss anomalies in the wall of a pipe or in a weld that may interact to weaken the pipeline more than either would individually.
Corrosion:	An electrochemical reaction of the pipe wall with its environment causing a loss of metal.
Crack:	A planar, two-dimensional feature with displacement of the fracture surfaces.
Debris:	Extraneous material in a pipeline which may interfere with the ILI tool.
Dent:	Distortion of the pipe wall resulting in a change of the internal diameter but not necessarily resulting in localised reduction of wall thickness.

Detection threshold:	Minimum detectable feature dimension.
Feature:	Indication, generated by non-destructive examination, of a pipeline.
Geometry tool	Configuration pig designed to record conditions, such as dents, wrinkles, ovalities, bend radius and angle, and occasionally indications of significant internal corrosion, by sensing the shape of the internal surface of the pipe.
Grinding:	Reduction in wall thickness by removal of material by hand filing or power disk grinding.
Gouge:	Mechanically induced metal-loss, which causes localised elongated grooves or cavities.
Heat affected zone:	The area around a weld where the metallurgy of the metal is altered by the rise in temperature caused by the welding process, but this is distinct from the weld itself. For the purpose of this specification it is considered to be within 3A of the centre line of the weld, where "A" is the geometrical parameter related to the wall thickness.
In-Line Inspection (ILI):	Inspection of a pipeline from the interior of the pipe using an In-Line Inspection tool..
In-Line Inspection tool	Device or vehicle, also known as an intelligent or smart pig, that uses a non-destructive testing technique to inspect the pipeline.
Intelligent pig:	Pig that can perform a non-destructive examination.
Joint:	Single section of pipe that is welded to others to make up a pipeline.
Lamination:	Imperfection or discontinuity with a layered separation, that may extend parallel or angular to the pipe wall surface.
Metal loss anomaly/feature:	An area of pipe wall with a measurable reduction in thickness.
Mid wall feature:	Any feature which does not run out to either the internal or external surface.
Measurement threshold	The minimum dimension(s) of a feature to make sizing possible.
Nominal wall thickness:	The wall thickness required by the specification for the manufacture of the pipe.
Pig:	Device that is driven through a pipeline for performing various internal activities (depending on the pig type) such as separating fluids, cleaning or inspecting the pipeline.
Pigging:	Running of a pig or ILI tool in a pipeline.
Pig Trap:	An ancillary item of pipeline equipment, with associated pipework and valves, for introducing a pig into a pipeline or removing a pig from a pipeline.
Pipeline:	A system of pipes and other components used for the transportation of products between (but excluding) plants. A pipeline extends from pig trap to pig trap (including the pig traps), or, if no pig trap is fitted, to the first isolation valve within the plant boundaries or a more inward valve if so nominated.

Pipe mill anomaly:	An anomaly that arises during manufacture of the pipe, as for instance a lap, sliver, lamination, non-metallic inclusion, roll mark and seam weld anomaly.
Pipeline component:	A feature such as a valve, tee, bend, weld, casing, marker, wall thickness change, etc. that is a normal and intentionally fitted part of a pipeline
Probability of Detection:	The probability of a feature being detected by the intelligent pig.
Probability of Identification:	The probability that an anomaly or a feature, once detected, will be correctly identified
Reference wall thickness:	The actual undiminished wall thickness surrounding a feature.
Reporting threshold:	Parameter, which defines whether or not a feature will be reported.
Sizing accuracy:	Sizing accuracy is given by the interval within which a fixed percentage of features will be sized. This fixed percentage is stated as the confidence level.
Spalling:	Abrasion of the pipe surface resulting in shallow surface laps and possibly hardening of the material below.
Weld:	The area where joining has been done by welding. This is distinct from the heat-affected zone, but is located within it.
Weld anomaly:	Anomaly in the body or the heat affected zone of a weld.

2.2 Abbreviations

A:	Geometric parameter related to the wall thickness
d:	Maximum metal loss anomaly depth
ERF:	Estimated repair factor
GPS	Global Positioning System
L:	Anomaly/feature dimension (Length) in the axial direction and length of crack in any direction
MAOP	Maximum allowable operating pressure
MOP:	Maximum operating pressure
MFL:	Magnetic flux leakage
NDE/NDT:	Non-destructive examination, Non-destructive testing
POD:	Probability of detection
POI:	Probability of identification
P_{safe}	Safe operation pressure as per calculated defect assessment method
t:	Wall thickness
UT:	Ultrasonic Technique
W:	Anomaly/feature dimension (Width) in the circumferential direction and opening dimension for cracks (if applicable).

2.3 Geometrical parameters and interaction of anomalies

Geometrical parameters of anomalies are length "L", width "W", depth "d" and reference wall thickness “t”. The parameter A is used for the geometrical classification of the anomalies detected by a tool. This parameter is needed for pipes with t<10 mm. The geometrical parameter A is linked to the NDE methods in the following manner:

If $t < 10$ mm then $A = 10$ mm
If $t \geq 10$ mm then $A = t$

The measurement threshold as indicated in Figure 1 determines the start and end point of an anomaly. Its projected length on the longitudinal axis of the pipe gives the length, "L", of an individual anomaly. The projected length of L between S (starting point) and E (ending point) shall be considered in the pigging direction. The width, "W", of an individual anomaly is given by its projected length on the circumference of the pipe. The projected length of W between S (starting point) and E (ending point) shall be considered in the clockwise direction, looking downstream. The measurement threshold may be set at the detection threshold or at some independent value according to the pipeline characteristics.

The intelligent pigging contractor should specify the measurement threshold. If no value is specified then the measurement threshold shall be taken at 5% for MFL tools and 0.5 mm for UT tools with respect to the reference wall thickness.

The depth of the metal loss "d" is determined by the maximum wall loss in an anomaly and can be given as a depth from or percentage of the reference wall thickness.

Unless the Client specifies otherwise, the following interaction rule (both steps) shall be applied:

Step 1: An anomaly (individual or part of a cluster) shall never be clustered with another adjacent anomaly (individual or part of a cluster) if the distance is >= 6t. This is applicable for the axial and circumferential direction.

Step 2: Individual anomalies shall be clustered when the axial spacing between the anomalies is less than the smallest anomaly and the circumferential spacing is less than the smallest anomaly feature width.

2.4 Nomenclature of features

Features are related to pipeline components or anomalies and can be distinguished in component features and anomaly features.

Features shall be typed in accordance with Appendix 3: Report structure (see column 4).

- Possible terminology for component feature typing is:
  Above Ground Marker, Additional metal/material, Anode, Crack arrestor begin/end, Casing begin/end, Change in wall thickness, CP connection, External support, Ground anchor, Off take, Pipeline fixture, Reference magnet, Repair, Tee, Valve, Weld, Other.

- Possible terminology for anomaly feature typing is: anomaly.

The typed features shall be identified in accordance with Appendix 3: Report structure (see column 5).

- The component features typed as additional metal/material, repair and weld can be further identified as:
  Additional metal/material: Debris, Touching metal to metal, Other
  Repair: Welded sleeve begin/-end, Composite sleeve begin/-end, Weld deposit begin/-end, Coating begin/-end, Other begin/-end.

Weld: Bend begin/-end, Change in diameter, Change in wall thickness, Adjacent tapering and no identification for all welds different from welds mentioned before.

- Possible terminology for anomaly feature identification is:
  Arc strike, Artificial defect, Buckle, Corrosion, Corrosion cluster, Crack, Dent, Dent with metal loss, Gouging, Grinding, Girth weld crack, Girth weld anomaly, HIC, Lamination, Longitudinal seam weld crack, Longitudinal weld anomaly, Ovality, Pipe mill anomaly, Pipe mill anomaly cluster, SCC, Spalling, Spiral weld crack, Spiral weld anomaly, Wrinkle, Other.

2.5 Anomaly dimension classification

The measurement capabilities of non-destructive examination techniques depend on the geometry of the metal loss anomalies. These metal loss anomaly classes have been defined as shown in Figure 2 to allow a proper specification of the measurement capabilities of the intelligent pig. Each anomaly class permits a large range of shapes. Within that shape a reference point is defined at which the POD is specified.

Anomaly dimension class	Definition	Reference point/size for the POD in terms of L x W
General:	{[W ≥ 3A] and [L ≥ 3A]}	4A x 4A
Pitting:	{([1A ≤ W < 6A] and [1A ≤ L < 6A] and [0.5 < L/W < 2]) and not ([W ≥ 3A] and [L ≥ 3A])}	2A x 2A
Axial grooving:	{[1A ≤ W < 3A] and [L/W ≥ 2]}	4A x 2A
Circumferential grooving:	{[L/W ≤ 0.5] and [1A ≤ L < 3A]}	2A x 4A
Pinhole:	{[0 < W < 1A] and [0 < L < 1A}}	½A x ½A
Axial slotting:	{[0 < W < 1A] and [L ≥ 1A]}	2A x ½A
Circumferential slotting:	{[W ≥ 1A] and [0 < L < 1A]}	½A x 2A

An even distribution of length, width and depth shall be assumed for each anomaly dimension class to derive a statistical measurement performance on sizing accuracy.

The reference point/size in the table above is the point/size at which the POD is specified.

2.6 Estimated repair factor

The estimated repair factor (ERF) is defined as:

$$ERF = MOP/P_{safe}$$

Where P_{safe} is the safe operating pressure as calculated by anomaly assessment method as agreed between client and contractor. Possible assessment methods, but not limited to are:

- B31 G.
  Manual for Determining the Remaining Strength of Corroded Pipelines: A Supplement to ASME B 31 Code for Pressure Piping; published by ASME International.

- Rstreng-2 (Modified B31 G).
  AGA Pipeline Research committee project PR-3-805, "A modified criterion for evaluating the remaining strength of corroded pipe" (Dec. 1989).

- DNV RP-F101

- Shell 92

2.7 Resolution of measurement parameters

The following units and resolution shall be used for the measurement parameters:

Definition	Metric units	Imperial units
Log distances:	0.001 m	0.1 inch
Feature length and width:	1 mm	0.01 inch
Feature depth:	0.1 mm or 1%	0.01"or 1%
Reference wall thickness	0.1 mm or 1%	0.01" or 1%
Orientation:	0.5° or 1 minute	1 minute
ERF:	0.01	0.01
Magnetic field H:	1 Am^{-1}	Oersted
Axial sampling distance:	0.1 mm	0.01 inch
Circumferential sensor spacing:	0.1 mm	0.01 inch
Tool speed:	0.1 m/s	0.1 ft/sec
Temperature:	1 °C	1 °F
Pressure:	0.01 MPa	0.1 PSI

3. Tool specifications

3.1 General tool specification

The most common tools for pipeline inspection are based on the MFL or UT techniques. For these techniques detailed tool specifications are given in the subsequent paragraphs. For tools operating with other technology, the given tool specifications can be used as a basis for the level of details required in order for the pipeline operator to perform an evaluation of the proposed system with regards to detection ability and sizing accuracy.

General tool specification, valid for all tool types:

- Wall thickness range
- Speed range
- Temperature range
- Maximum pressure
- Minimum pressure for operation
- Minimum bend radius
- Minimum internal diameter

- Tool length, weight and number of bodies
- Differential pressure required to run and launch the tool
- Minimum and maximum length of pipeline that can be inspected in one run (may be coupled to run times and state of the pipeline
- Minimum length for launcher
- Minimum distance between gate and reducer in the receiver.
- Type of batteries
- Indication of by pass flow in case of tool stuck

3.2 MFL tool specifications

Based on the direction of magnetization, at least two types of tools are available. The standard MFL tool that magnetises the pipe wall in the axial direction, has limited sensitivity to axial aligned defects. MFL tools that magnetises the pipe wall in the circumferential direction are more sensitive for axially aligned metal loss, but are likely to have different specifications. A diagonally magnetisation tool might be a compromise. If the specifications of more type of tools are requested, then individual tables shall be supplied.

MFL tool specifications shall include:

- Direction of magnetisation (axial/circumferential/diagonal)
- The magnetic field strength H in Am^{-1} as function of wall thickness
- Required minimal magnetic field strength H in Am^{-1} to meet the given POD and accuracy
- Axial sampling frequency or distance
- Nominal circumferential spacing of measuring sensors
- Nominal circumferential spacing of ID/OD discriminating sensors (if present)
- Location accuracy of the features with respect to the upstream girth weld, the upstream marker and the orientation in the pipe

.

The measurement specification shall include the Tables 1 to 5 where they apply. Optionally, pinhole features, axial slotting features and circumferential slotting features can be added to the tables.

It is recognized that the probability of detection of a feature is highly dependent on pipe wall magnetization for MFL pigs. Tables 2 and 3 shall therefore be linked, in case of MFL pigs, to pipe wall magnetization ranges whereby the specifications shall apply for the minimum pipe wall magnetization, tool velocity and also to the pipeline make (i.e. seamless pipe vs seam-welded pipe).

If crack detection is possible and is included in the inspection scope of work, the contractor shall provide the following parameters:

- Minimum depth, length and opening dimension of a crack to be detectable
- The confidence level for the detection of this minimum crack
- The accuracy of sizing of crack length and depth
- The confidence level for the sizing performance

3.3 UT tool specifications - metal loss detection

UT-metal loss detection tool specification shall include:

- Axial sampling frequency or distance
- Nominal circumferential spacing of measuring sensors
- Diameter/dimensions of UT transducers
- Frequency of UT transducers
- Stand-off distance of UT transducers

The measurement specification shall include the tables 1 to 5 where they apply. .

3.4 UT tool specifications - crack detection

UT-crack detection tool specification shall include:

- Tool length, weight and number of bodies
- Axial sampling frequency or distance
- Nominal circumferential spacing of measuring sensors
- Dimensions of UT transducers
- Frequency of UT transducers
- Angle of UT signal in steel
- Direction of angle of UT signal relative to pipe axis (i.e. longitudinal direction is 0º, circumferential is 90º)
- Minimum depth and length for a crack to be detectable
- The confidence level for the detection of this minimum crack
- The accuracy of sizing of crack length and depth
- The confidence level for the sizing performance

The measurement specification shall include tables 1 and 4.

3.5 Geometry tool specifications

Geometry tool specifications shall include

- Axial sampling frequency or distance
- Nominal circumferential spacing of measuring sensors or resolution of circumferential measurements
- Amount of circumferential not covered by sensors (i.e. dimensions of gaps between sensors)
- Minimum detectable deformation* dimensions (depth, length, width)
- Minimum/maximum ovality measurement dimension
- Number of sensor recorded continuously.
- Presence and resolution of clock position indicator
- Location accuracy of the features with respect to the upstream girth weld, the upstream marker and the log distance

* Deformation includes dents, wrinkles, buckles.

The measurement specification shall include tables 1 and 5.

3.6 Geographic tool specifications

Pipeline geographical units are often attached to an MFL or UT inspection tool, whereby the inspection unit has a double functionality. The specifications of the geographic equipment is quite different and requires a specific list.

The measurement specification shall include table 1 and 6.

The required specification list and further details will be inserted at a later stage.

4. Reporting requirements

The requirements herein may be changed at the client's request. If more than one tool has been applied (i.e. MFL and Geometry) and/or the functionality of the tools has been combined in one tool (i.e. MFL and Geographic tool), then the information of both tools or units shall be combined in one pipe tally and in one list of anomalies.

The field report shall contain a statement of the contractor on the quality of the inspection run.

The final inspection report (hard & electronic copy) of either a single or combined ILI tool run shall contain the following information:

- Tool operational data
- Pipe tally
- List of anomalies
- Summary and statistical data
- Fully assessed feature sheets
- Defect assessment method

The list of anomalies and the pipe tally shall be compatible with standard CSV or DBF files compatible with EXCEL files.

In addition to the hard copy a user friendly software package shall be provided to enable review and assessment of the data collected by the inspection tool.

4.1 Tool operational data

The tool specifications shall be given. In addition the following operational data shall be provided, whereby each type of tool that has been used shall be described separately:

- The data-sampling frequency or distance
- The detection threshold
- The reporting threshold, normally taken at 90% POD if not specified otherwise
- A tool velocity plot over the length of the pipeline
- Optionally, a pressure and/or temperature plot over the length of the pipeline
- Defective transducer statistics
- In case of MFL tools, the magnetic field strength H in Am^{-1} over the length of the pipeline
- In case of ultrasonic pigs, echo loss statistics

The tool operational data shall indicate whether the tool has functioned according to specification. It shall detail all locations of data loss and where the measurement specifications are not met.

The formulation of maximum acceptable data loss for MFL tools can be specified as:

- The maximum acceptable sensor loss (primary sensors) for MFL tools is 3% and continuous loss of data from more than three adjacent sensors or 25mm circumference (whichever is smallest) at critical places (i.e. bottom of line) is not acceptable.

- The POD of a defect with minimum dimensions for a minimum percentage of the pipeline surface and pipeline length. I .e. a defect with L≥20mm, W≥20mm, d≥20% t shall be detected with a POD≥90% for ≥ 97% of the pipeline surface and ≥ 97% of the pipeline length.

The formulation of maximum acceptable data loss for UT tools can be specified as:

- The maximum acceptable sensor loss for UT tools is 3% and the maximum allowable signal loss due to other reasons (i.e. echo loss) is 5%, whereby continuous loss of data from more than two adjacent transducers or 25mm circumference (whichever is smallest) at critical places (i.e. bottom of line) is not acceptable, or:

- The POD of a defect with minimum dimensions for a minimum percentage of the pipeline surface and pipeline length. I .e. a defect with L≥20 mm, W≥20 mm, d≥1 mm shall be detected with a POD≥90% for ≥ 97% of the pipeline surface and ≥ 97% of the pipeline length.

4.2 Pipe tally

The pipe tally shall be a listing of all pipeline component features and anomaly features and be reported in accordance (including terminology) with the report structure as given in Appendix 3: Report structure. If not agreed otherwise between client and contractor, the pipe tally shall contain the following fields in the given sequence:

- Log distance
- Up stream weld distance
- Joint length
- Feature type (for terminology, see column 4 of Appendix 3: Report structure)
- Feature identification (for terminology, see column 5 of Appendix 3: Report structure)
- Anomaly dimension classification (see Fig. 2)
- Clock position (see Fig. 1)
- Nominal t (of each joint or pipeline component, between girth welds, as measured by the tool).
- Reference t (for UT tools, see below)
- Length of anomaly/feature
- Width of anomaly/feature
- d/t in % for MFL and d in mm or inch for UT
- Surface location (int., ext., mid wall or N/A, see column 14, Appendix 3: Report structure)
- ERF

- Comments

For ultrasonic tools, the pipe tally shall give the reference wall thickness of each pipe joint as measured by the tool. Where there is a variation in the reference wall thickness over the length of the joint, the most frequently measured reference wall thickness shall be given. If agreed by client and contractor the minimum or average wall thickness can be given as reference wall thickness also.

4.3 List of anomalies

All anomalies with dimensions above the reporting threshold at 90% POD or above a reporting threshold as specified by the Client shall be reported in the List of anomalies.

If not agreed otherwise between client and contractor, the List of anomalies shall contain the same fields as the pipe tally. The field “Feature type” refers to anomalies, while the field “Feature identification” specifies these anomalies with one of the following possible items (see Appendix 3: Report structure columns 4 and 5):

Arc strike, Artificial defect, Buckle, Corrosion, Corrosion cluster, Crack, Dent, Dent with metal loss, Gouging, Grinding, Girth weld crack, Girth weld anomaly, HIC (hydrogen induced cracking), Lamination, Longitudinal seam weld crack, Longitudinal weld anomaly, Ovality Pipe mill anomaly, Pipe mill anomaly cluster, SCC (Stress Corrosion Cracking), Spalling, Spiral weld crack, Spiral weld anomaly, Wrinkle, Other.

The List of Anomalies shall contain the clusters (according to 2.3) and the not clustered (individual) anomalies. Additionally the individual anomalies forming the reported cluster (see 2.3) shall be listed in the final inspection report whereby the relation between the anomalies and clusters are indicated (i.e. numbered).
On the client’s request also the location of the deepest point in the metal loss area or clustered area shall be reported.

4.4 Summary and statistical report

4.4.1 Summary and statistical report of metal loss tools

The summary report of metal loss tools shall contain a listing of:

- Total number of anomalies
- Number of internal anomalies
- Number of external anomalies
- Number of general anomalies
- Number of pits
- Number of axial and circumferential grooves
- Number of anomalies with depth 0 – <10%t
- Number of anomalies with depth 10 – <20%t
- Number of anomalies with depth 20 – <30%t
- Number of anomalies with depth 30 – <40%t
- Number of anomalies with depth 40 – <50%t
- Number of anomalies with depth 50 – <60%t
- Number of anomalies with depth 60 – <70%t
- Number of anomalies with depth 70 – <80%t

- Number of anomalies with depth 80 – <90%t
- Number of anomalies with depth 90 - 100%t
- Number of anomalies with ERF 0.6 – <0.8
- Number of anomalies with ERF 0.8 – <0.9
- Number of anomalies with ERF 0.9 – <1.0
- Number of anomalies with ERF ≥ 1.0

The following histograms shall be provided over the entire pipeline length:

- Number of anomalies in 500 m section with depth < 0.4t
- Number of anomalies in 500 m sections with depth 0.4t – <0.6t
- Number of anomalies in 500 m sections with depth 0.6t – <80t
- Number of anomalies in 500 m sections with depth ≥0.8t
- Number of anomalies in 500 m sections with ERF 0.8 – <1.0
- Number of anomalies in 500 m sections with ERF ≥1.0

The following plots shall be provided:

- Sentenced plot including ERF=1 curve of anomaly length against metal-loss feature depth showing all anomalies for the predominant wall thickness
- Orientation* plot of all anomalies over the full pipeline length
- Orientation* plot of all internal anomalies over the full pipeline length
- Orientation* plot of all external anomalies over the full pipeline length
- Orientation* plot of all anomalies as function of relative distance to the closest girth weld

* If not specified otherwise, the orientation of the anomalies is point S (see 2.3).

4.4.2 Summary and statistical report of geometry tools

The summary report of geometry tools shall contain a listing of:

- Total number of dents
- Total number of ovalities
- Number of dents with depth 2 – <6% ID
- Number of dents with depth ≥ 6% ID
- Number of ovalities** 0.10 > ratio < 0.05
- Number of ovalities** with ratio ≥ 0.10
- Orientation* plot of all dents over the full pipeline length
- Orientation* plot of all ovalities over the full pipeline length

* If not specified otherwise, the orientation of the anomalies is point S (see 2.3).
** For applied definition of ovality see table 5. By agreement between Client and Contractor another definition and/or reporting windows can be specified.

4.5 Fully assessed feature sheets (dig up sheets)

Fully assessed feature sheets shall be provided as a minimum for the 10 most serious metal loss indications. Selection of the most serious metal loss indications can be based on depth or pressure, to be defined in Technical Scope of Work in the Contract. If not specified otherwise, the selection of 5 anomalies will be depth based and the other 5 pressure based. By agreement between contractor and client the selection can be based on ERF.

Fully assessed feature sheets shall contain the following information to the full sizing specification:

- Length of pipe joint and (when present) orientation of longitudinal or spiral seam at start and end of every joint;
- Length and longitudinal or spiral seam orientation of the 3 upstream and 3 downstream neighbouring pipe joints;
- Log distance of metal loss feature;
- Wall thickness of the pipe joints (up to the 3 upstream and 3 downstream joints);
- Log distance of features (with location coordinates known by client) like magnet markers, fixtures, steel casings, tees, valves, etc on the first three upstream and downstream pipe joints;
- Distance of upstream girth weld to nearest, second and third upstream marker;
- Distance of upstream girth weld to nearest, second and third downstream marker;
- Distance of anomaly to upstream girth weld;
- Distance of anomaly to downstream girth weld;
- Orientation of anomaly;
- Anomaly description and dimensions;
- Internal/external/mid-wall indication.

4.6 Corrosion Growth Report

On request of the Client a corrosion growth report shall be supplied and/or the Client might request the availability of raw inspection data to allow for corrosion growth analysis at a later stage.

A corrosion growth report shall, as a minimum, include confidence and accuracies of the reported corrosion growth or growth rate.

Some considerations:
A number of important Pipeline Integrity Management Program decisions depend on reliable and realistic corrosion growth rate estimates. Various methods are available for estimating internal and/or external corrosion rates on pipelines. These methods include but are not limited to:

- *Comparison with corrosion rates found on other pipelines (data base),*
- *Direct assessment methods relating corrosion rates to conditions found in the field,*
- *Simple methods based on "actual" depth reported by ILI or field data and estimated duration of corrosion (ref API 570 and 579),*
- *Comparison of results of multiple ILI runs at specific defect locations.*

Each method provides practical benefits and imposes limitations depending on the type of decision required. A thorough understanding of the methods available and conditions for their use is essential to operators making the corrosion decisions related to their Integrity Management Program. For this reason it is envisaged that well-balanced requirements should be developed and it is the aim of the POF to inform the members about the available corrosion growth estimate methods and requirements in the next version of this document.

Table 1: Identification of features

Feature	**Yes POI>90%**	**No POI<50%**	**May be 50%<=POI<=90%**
Int./ext./midwall discrimination			
Additional metal/material:			
- debris			
- touching metal to metal			
Anode			
Anomaly:			
- arc strike			
- artificial defect			
- buckle			
- corrosion			
- corrosion cluster			
- crack			
- dent			
- dent with metal loss			
- gouging			
- grinding			
- girth weld crack			
- girth weld anomaly			
- HIC			
- lamination			
- longitudinal weld crack			
- longitudinal weld anomaly			
- ovality			
- pipe mill anomaly			
- pipe mill feature anomaly			

- SCC			
- spalling			
- spiral weld crack			
- spiral weld anomaly			
- wrinkle			
Crack arrestor			
Eccentric pipeline casing			
Change in wall thickness			
CP connection			
External support			
Ground anchor			
Off take			
Pipeline fixture			
Reference magnet			
Repair:			
- welded sleeve repair			
- composite sleeve repair			
- weld deposit			
- coating			
Tee			
Valve			
Weld:			
- bend			
- diameter change			
- wall thickness change (pipe/pipe connection)			
- adjacent tapering			

Table 2: Detection and sizing accuracy for anomalies in body of pipe

	General metal-loss		Pitting		Axial grooving		Circumf. grooving	
Depth at POD=90%								
	80%	90%	80%	90%	80%	90%	80%	90%
Depth sizing accuracy at 80 and 90% confidence								
Width sizing accuracy at 80 and 90% confidence								
Length sizing accuracy at 80 and 90% confidence								

Table 3: Detection and sizing accuracy for anomalies in girth weld or heat affected zone

	General metal-loss	Pitting	Axial grooving	Circumf. grooving
Depth at POD=90%				
Depth sizing accuracy at 80% confidence				
Width sizing accuracy at 80% confidence				
Length sizing accuracy at 80% confidence				

Table 4: Detection and sizing accuracy for crack or crack-like defects.

	Axial crack	Circumferential crack	Spiral crack
Depth at POD=90% of crack with L=250 mm			
Minimum crack opening (mm)			
Depth sizing accuracy at 80% confidence			
Length sizing accuracy at 80% confidence			

Table 5: Detection and sizing accuracy for dents and ovalities

	Dent	Ovality*
Depth at POD=90%		n.a.
Depth sizing accuracy at 80% confidence		n.a.
Width sizing accuracy at 80% confidence		n.a.
Length sizing accuracy at 80% confidence		
Ovality at POD=90%		

*Ovality = (IDmax-IDmin) / (IDmax+IDmin)

Table 6: Accuracy of pipeline location

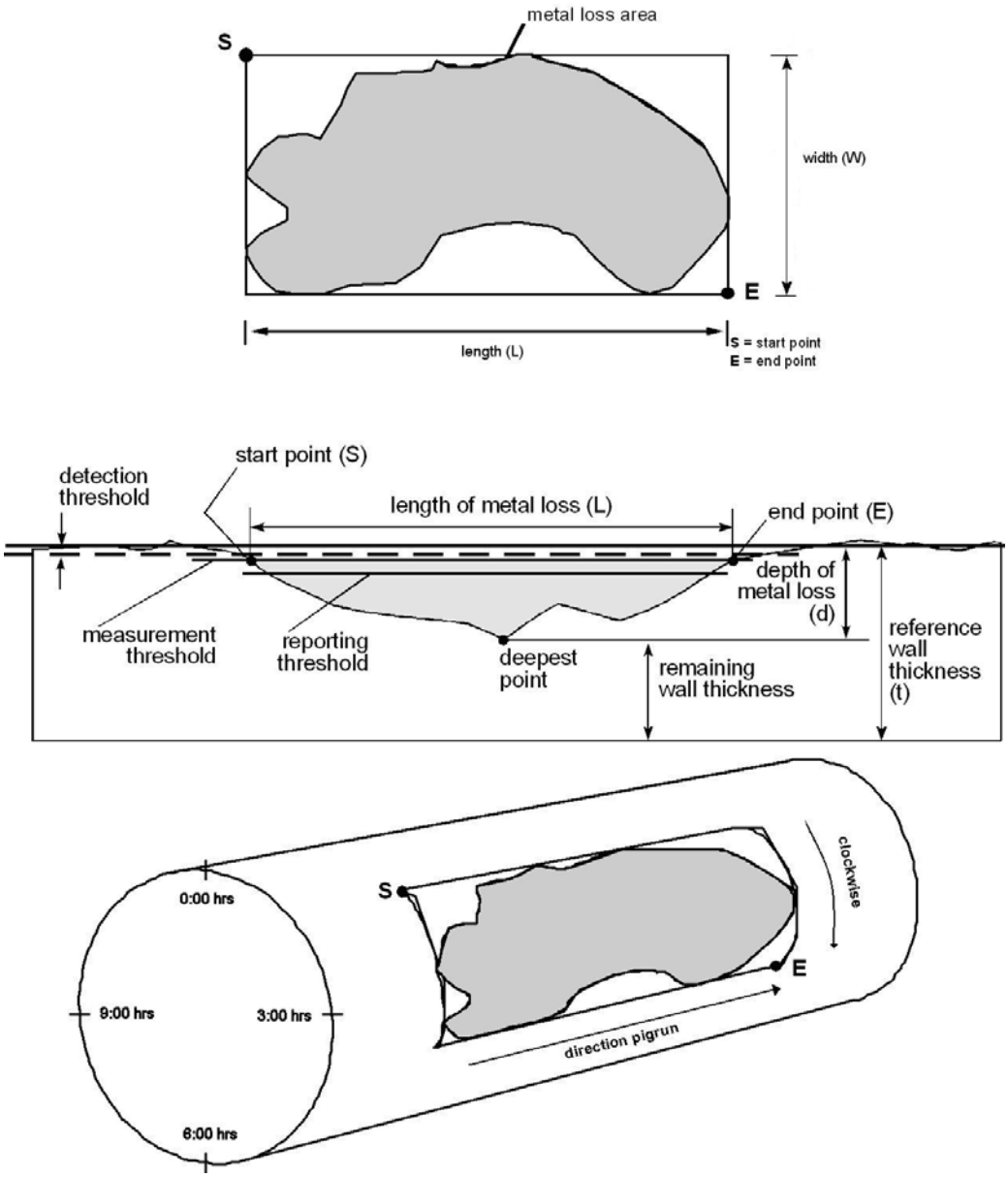
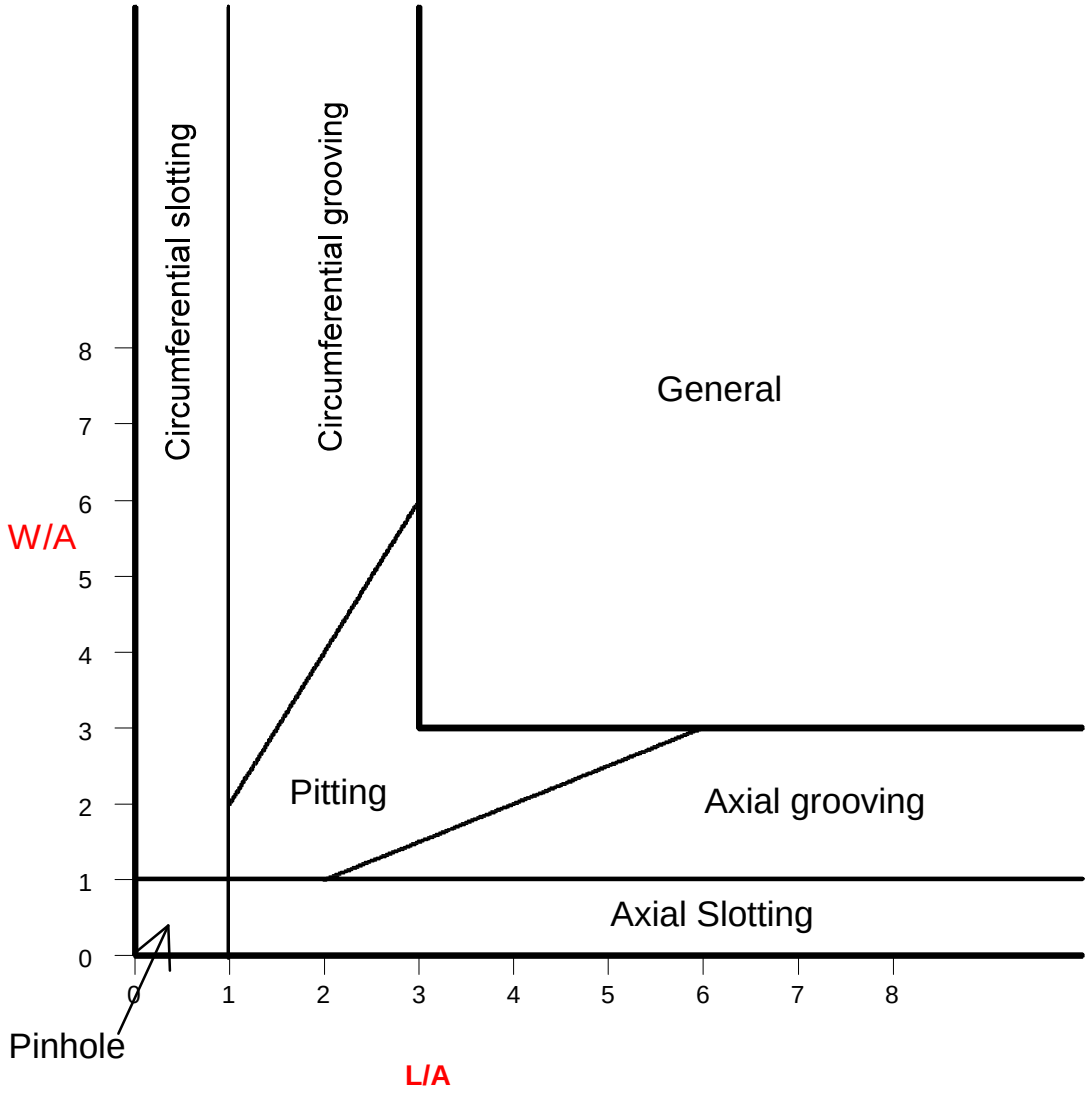


Figure 1: Location and dimensions of metal loss anomaly.



The geometrical parameter A is linked to the NDE methods in the following manner:

If $t < 10$ mm then $A = 10$ mm
If $t \geq 10$ mm then $A = t$

Figure 2: Graphical presentation of metal loss anomalies per dimension class.

Appendix 1

Members of Pipeline Operator Forum

POF MEMBER COMPANIES

BP

ConocoPhillips Norway

Enagas

Exxonmobil

Gassco

Gasunie

Gaz de France

MOL

Norsk Hydro

OMV Gas GmbH

Qatar Petroleum

Ruhrgas

Shell European Oil Prod.

Shell Global Solutions

Shell U.K. Expl. & Prod.

Statoil

Total SA

Transalpine Pipeline

Appendix 2

ILI companies approached for comments to draft specifications

COMPANY	Country	WEBSITE
Baker Hughes/CPIG	Canada	www.bakerhughes.com/PMG
BJ Pipeline Inspection Services	Canada	www.bjservices.com
GE/PII	United Kingdom	www.gepower.com
Magpie/TDW	USA	www.magpiesystems.com
NDT	Germany	www.ndt-ag.de
NGKS	Russia	www.ngksint.com
Pipecare	Norway	www.pipecare.com
3P Services	Germany	www.3p-services.com
Rosen	Germany	www. Roseninspection.net
Tuboscope	USA	www.tuboscope.com

Appendix 3: Report structure

Column no.	Column title	Unit	Prescribed terminology	Abbreviate	Explanatory note
1	Log distance	m	-		Starting point: scraper trap valve
2	Up weld dist.	m	-		Distance to upstream weld
3	L joint	m	-		Joint length to downstream weld
4	Feature type	-	- Above Ground Marker - Additional metal/material - Anode - Anomaly - Crack arrestor begin / -end - Casing begin / -end - Change in wall thickness - CP connection - External support - Ground anchor - Off take - Other - Pipeline fixture - Reference magnet - Repair - Tee - Valve - Weld	AGM ADME ANOD ANOM CRAB/CRAE CASB/CASE CHWT CPCO ESUP ANCH OFFT OTHE PFIX MGNT REPA TEE VALV WELD	
5	Feature identification	-	Additional metal/material: - Debris - Touching metal to metal - Other Anomaly: - Arc strike - Artificial defect - Buckle - Corrosion - Corrosion cluster - Crack - Dent - Dent with metal loss - Gouging - Grinding - Girth weld crack - Girth weld anomaly - HIC - Lamination - Longitudinal seam weld crack - Longitudinal weld anomaly - Ovality - Pipe mill anomaly - Pipe mill anomaly cluster - SCC - Spalling - Spiral weld crack - Spiral weld anomaly - Wrinkle	 DEBR TMTM OTHE ARCS ARTD BUCK CORR COCL CRAC DENT DEML GOUG GRIN GWCR GWAN HIC LAMI LWCR LWAN OVAL MIAN MIAC SCC SPAL SWCR SWAN WRIN	

			- Other <u>Repair:</u> - Welded sleeve begin / -end - Composite sleeve begin / -end - Weld deposit begin / -end - Coating begin / -end - Other begin / -end <u>Weld:</u> - - Bend begin / -end - Change in diameter - Change in wall thickness - Adjacent tapering	OTHE WSLB/WSLE CSLB/CSLE WDPB/WDP E COTB/COTE OTHB/OTHE BENB/BENE CHDI CHWT ADTA	 All Welds different from welds mentioned below Applicable for: Pipe – pipe unequal WT
6	Feature class		- Axial Grooving - Axial Slotting - Circumferential Grooving - Circumferential Slotting - General - Pinhole - Pitting	AXGR AXSL CIGR CISL GENE PINH PITT	See Fig. 2
7	Clock position	h:min			See Fig. 1
8	Nominal t	mm			Nominal wall thickness of every joint
9	Reference t	mm			The actual not diminished wall thickness surrounding a feature
10	Length	mm			Anomaly length in axial direction
11	Width	mm			Anomaly width in circumferential direction
12	d (peak)	%			Peak depth % of ref. t or nom. t (if ref. t is not available)
13	d (mean)	%			Mean depth % of ref. t or nom. t (if ref. t is not available)
14	Surface location	-	- INT - EXT - MID - N/A		Location of anomaly on the pipeline: internal, external, mid wall or Not Applicable
15	ERF				
16	Comments	-	-		-

Appendix 3: Report structure, Example pipe tally

Log distance (m)	Up weld dist. (m)	L joint (m)	Feature type (Component and Anomaly)	Feature identification (Component and Anomaly)	Anomaly Dimension class	Clock position h:min	Nominal t (mm)	Reference t (mm)	Length (mm)	Width (mm)	d (peak) %	d (mean) %	Surface location	ERF	Comments
11158.68	-	15.38	Weld (WELD)	-	-	-	14.3	-	-	-	-	-	-	-	-
11161.33	2.65	-	Above Ground Marker (AGM)	-	-	-	14.3	-	-	-	-	-	-	-	AGM nr. 6
11163.58	4.90	-	Anomaly (ANOM)	Gouging (GOUG)	CIGR	10:28	14.3	-	23	254	28	16	EXT	-	-
11165.90	7.22	-	Anomaly (ANOM)	Corrosion cluster (COCL)	GENE	5:12	14.3	-	392	188	17	11	EXT	0.94	-
11174.06	-	12.16	Weld (WELD)	Change in wall thickness (CHWT)	-	-	12.4	-	-	-	-	-	-	-	-
11175.28	1.22	-	Anomaly (ANOM)	Dent (DENT)	-	0:18	12.4	-	-	-	-	-	-	-	2.5 % Dent depth
11177.46	3.40	-	Anomaly (ANOM)	Dent with metal Loss (DEML)	-	12:08	12.4	-	112	7	16	9	-	-	5.5 % Dent depth
1178.96	4.90	-	Anomaly (ANOM)	Pipe mill anomaly cluster (MIAC)	GENE	10:15	12.4	-	401	889	25	12	INT	-	-
11183.15	9.09	-	Anomaly (ANOM)	Pipe mill anomaly (MIAN)	CIGR	6:12	12.4	-	17	55	15	9	EXT	-	-
11183.32	9.26	-	Casing begin (CASB)	-	-	-	12.4	-	-	-	-	-	-	-	Mainstreet
11185.96	11.90	-	Casing end (CASE)	-	-	-	12.4	-	-	-	-	-	-	-	-
11186.22	-	12.48	Weld (WELD)	-	-	-	12.4	-	-	-	-	-	-	-	-
11187.97	1.75	-	Anomaly (ANOM)	Longitudinal weld anomaly (LWAN)	PITT	2:09	12.4	-	39	26	15	8	EXT	-	-
11198.70	-	12.56	Weld (WELD)	Change in wall thickness (CHWT)	-	-	11.2	-	-	-	-	-	-	-	-
11198.70	0.00	-	Anomaly (ANOM)	Girth weld anomaly (GWAN	CIGR	4:06	11.2	-	14	131	10	6	N/A	-	-

111202.35	3.65	-	Anomaly (ANOM)	Grinding (GRIN)	CIGR	6:6	11.2	-	16	43	16	4	EXT	-	-
11203.01	4.31	-	Additional metal / material (ADME)	Touching metal to metal (TMTM)	-	1:46	11.2	-	-	-	-	-	-	-	-
11211.26	-	3.00	Weld (WELD)	-	-	-	20.4	-	-	-	-	-	-	-	Installation S114-01
11212.76	1.50		Tee (TEE)	-	-	3:00	20.4	-	-	-	-	-	-	-	Installation S114-01
11214.26	-	3.50	Weld (WELD)	-	-	-	30.8	-	-	-	-	-	-	-	Installation S114-01
11216.01	1.75		Valve (VALV)	-	-	12:00	30.8	-	-	-	-	-	-	-	Installation S1140
11217.76	-	2.20	Weld (WELD)	Bend begin (BENB)	-	-	18.2	-	-	-	-	-	-	-	Installation S1140
11219.96	-	12.54	Weld (WELD)	Bend end (BENE)	-	-	11.2	-	-	-	-	-	-	-	Installation S1140
11232.50	-	13.02	Weld (WELD)	-	-	-	11.2	-	-	-	-	-	-	-	-
11232.75	0.25	-	Anomaly (ANOM)	Corrosion (CORR)	PITT	6:11	11.2	-	10	17	17	11	EXT	0.91	-
11245.52	-	12.30	Weld (WELD)	-	-	-	11.2	-	-	-	-	-	-	-	-
11257.82	-	11.20	Weld (WELD)	Bend begin (BENB)	-	-	11.2	-	-	-	-	-	-	-	-
11269.02	-	12.04	Weld (WELD)	Bend end (BENE)	-	-	11.2	-	-	-	-	-	-	-	-
11281.06	-	12.09	Weld (WELD)	-	-	-	11.2	-	-	-	-	-	-	-	-
11292.61	11.55	-	Repair (REPA)	Welded sleeve begin (WSLB)	-	-	11.2	-	-	-	-	-	-	-	-
11293.06	12.00	-	Anomaly (ANOM)	Corrosion (CORR)	CIGR	7:09	11.2	-	23	65	13	11	EXT	0.91	-
11293.15	-	12.54	Weld (WELD)	-	-	-	11.2	-	-	-	-	-	-	-	-
11293.31	0.16	-	Anomaly (ANOM)	Corrosion (CORR)	AXGR	6:23	11.2	-	126	16	21	12	EXT	0.94	-
11293.38	0.23	-	Anomaly (ANOM)	Corrosion (CORR)	GENE	8:12	11.2	-	36	40	17	12	EXT	0.91	-
11293.67	0.52	-	Repair (REPA)	Welded sleeve end (WSLE)	-	-	11.2	-	-	-	-	-	-	-	-
11305.69	-	12.54	Weld (WELD)	-	-	-	11.2	-	-	-	-	-	-	-	-

Appendix 3: Report structure, Example List of Anomalies

Log distance (m)	Up weld dist. (m)	L joint (m)	Anomaly Feature type	Anomaly Feature identification	Anomaly Dimension class	Clock position h:min	Nominal t (mm)	Length (mm)	Width (mm)	d (peak) %	d (mean) %	Surface location	ERF	Comments
11163.58	4.90	-	Anomaly (ANOM)	Gouging (GOUG)	CIGR	10:28	14.3	23	254	28	16	EXT	-	-
11165.90	7.22	-	Anomaly (ANOM)	Corrosion cluster (COCL)	GENE	5:12	14.3	392	188	17	11	EXT	0.94	-
11175.28	1.22	-	Anomaly (ANOM)	Dent (DENT)	-	0:17	12.4	-	-	-	-	-	-	2.5 % Dent depth
11177.46	3.40	-	Anomaly (ANOM)	Dent with metal Loss (DEML)	-	12:01	12.4	112	7	16	9	-	-	5.5 % Dent depth
1178.96	4.90	-	Anomaly (ANOM)	Pipe mill anomaly Cluster (MIAC)	GENE	10:15	12.4	401	889	25	12	INT	-	-
11183.15	9.09	-	Anomaly (ANOM)	Pipe mill anomaly (MIAN)	CIGR	6:13	12.4	17	55	15	9	EXT	-	-
11187.97	1.75	-	Anomaly (ANOM)	Longitudinal weld anomaly (LWAN)	PITT	2:09	12.4	39	26	15	8	EXT	-	-
11198.70	0.00	-	Anomaly (ANOM)	Girth weld anomaly (GWAN)	CIGR	4:08	11.2	14	131	10	6	N/A	-	-
111202.35	3.65	-	Anomaly (ANOM)	Grinding (GRIN)	CIGR	6:31	11.2	16	43	16	4	EXT	-	-
11232.75	0.25	-	Anomaly (ANOM)	Corrosion (CORR)	PITT	6:11	11.2	10	17	17	11	EXT	0.91	-
11293.06	12.00	-	Anomaly (ANOM)	Corrosion (CORR)	CIGR	7:08	11.2	23	65	13	11	EXT	0.91	-
11293.31	0.16	-	Anomaly (ANOM)	Corrosion (CORR)	AXGR	6:04	11.2	126	16	21	12	EXT	0.94	-
11293.38	0.23	-	Anomaly (ANOM)	Corrosion (CORR)	GENE	8:19	11.2	36	40	17	12	EXT	0.91	-

Appendix 3: Report structure, Abbreviations

Column title	Prescribed terminology	Abbreviate
Feature type	- Above Ground Marker	AGM
	- Additional metal/material	ADME
	- Anode	ANOD
	- Anomaly	ANOM
	- Crack arrestor begin / -end	CRAB/CRAE
	- Casing begin / -end	CASB/CASE
	- Change in wall thickness	CHWT
	- CP connection	CPCO
	- External support	ESUP
	- Ground anchor	ANCH
	- Off take	OFFT
	- Other	OTHE
	- Pipeline fixture	PFIX
	- Reference magnet	MGNT
	- Repair	REPA
	- Tee	TEE
	- Valve	VALV
	- Weld	WELD
Feature identification	Additional metal/material:	
	- Debris	DEBR
	- Touching metal to metal	TMTM
	- Other	OTHE
	Anomaly:	
	- Arc strike	ARCS
	- Artificial defect	ARTD
	- Buckle	BUCK
	- Corrosion	CORR
	- Corrosion cluster	COCL
	- Crack	CRAC
	- Dent	DENT
	- Dent with metal loss	DEML
	- Gouging	GOUG
	- Grinding	GRIN
	- Girth weld crack	GWCR
	- Girth weld anomaly	GWAN
	- HIC	HIC
	- Lamination	LAMI
	- Longitudinal seam weld crack	LWCR
	- Longitudinal weld anomaly	LWAN
	- Ovality	OVAL
	- Pipe mill anomaly	MIAN
	- Pipe mill anomaly cluster	MIAC
	- SCC	SCC
	- Spalling	SPAL
	- Spiral weld crack	SWCR
	- Spiral weld anomaly	SWAN
	- Wrinkle	WRIN
	- Other	OTHE
	Repair:	
	- Welded sleeve begin /-end	WSLB/WSLE
	- Composite sleeve begin /-end	CSLB/CSLE
	- Weld deposit begin /-end	WDPB/WDPE
	- Coating begin /-end	COTB/COTE
	- Other begin /-end	OTHB/OTHE

	Weld: - Bend begin /-end - Change in diameter - Change in wall thickness - Adjacent Tapering	 BENB/BENE CHDI CHWT ADTA
Anomaly dimension class	- Axial Grooving - Axial Slotting - Circumferential Grooving - Circumferential Slotting - General - Pinhole - Pitting	AXGR AXSL CIGR CISL GENE PINH PITT