Specifications and requirements for intelligent pig inspection of pipelines

Version 2009

PIPELINE
OPERATORS FORUM

Contents

1. Introduction

This document specifies the advised operational and reporting requirements for tools to be used for geometric measurement, pipeline mapping, metal loss, crack or other anomaly detection during their passage through steel pipelines. The tools may pass through the pipeline driven by the flow of a medium 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.

This document has been reviewed and approved by the Pipeline Operator Forum (POF). It is stated however, that neither the members of the POF nor the Companies they represent can be hold responsible for the fitness for purpose, completeness, accuracy and/or application of this document.

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

During the update of this specification, the API 1163 “In-Line Inspection Systems Qualification Standard” have been reviewed and some terminology has been brought in-line (e.g. confidence changed into certainty).

This document is intended to serve as a generic in-line-inspection specification and thereby cannot cover all pipeline or pipeline operator specific issues. POF members and other users of this specification are therefore free to add or change requirements based on their specific pipeline situation. To support the pipeline operator in specifying/detailing some optional items in this document, a guideline with a short description of these items is given in Appendix 1.

2. Standardisation

2.1 Definitions

Above Ground Marker:	A device near the outside of a pipeline that detects and records the passage of an ILI tool or transmits a signal that is detected and recorded by the tool. Reference magnets can be applied to serve identical purposes.
Anomaly:	An indication, detected 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, landslides, washouts, frost heaves, earthquakes, etc
Casing:	A type of feature consisting of a larger diameter pipe placed concentrically around the pipeline, usually in high stress areas such as road crossings.

Certainty:	For the purpose of this specification, the probability that the characteristics of a reported anomaly are within the stated tolerances.
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.
Confidence level	A statistical expression used to describe the mathematical certainty with which a statement is made
Corrosion:	An electrochemical reaction of the pipe wall with its environment causing a loss of metal.
Crack:	A planar, two-dimensional feature with possible 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, detected 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. The width of the heat-affected zone is typically limited to a few mm only, depending on the welding process and parameters. For the purpose of this specification it is considered to be within 2A 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 from the inside.
Intelligent pig:	See “In-Line-Inspection tool”.
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.
Measured wall thickness:	Measured wall thickness that is representative for a whole pipe joint/component. For ultrasonic tools the value shall be based on direct wall thickness measurements, for magnetic tools on the inferred magnetic flux signals.
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, off take, wall thickness change, etc. that is a 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 magnet:	See Above Ground Marker
Reference wall thickness:	The actual undiminished wall thickness surrounding a feature, used as reference for the determination of the feature depth.
Reporting threshold:	Parameter, which defines whether or not a feature will be reported.

Sizing accuracy:	Sizing accuracy is given by the interval with which a fixed percentage of features will be sized. This fixed percentage is stated as the certainty 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 and where the material has undergone a melting and solidification process. This area is distinct from the heat-affected zone, but surrounded by it.
Weld anomaly:	Anomaly in the weld or the heat affected zone.
Weld affected area:	Area on both sides of a weld where ILI measurements are effected by the geometry of the weld (e.g. due to sensor dynamics).

2.2 Abbreviations

A	Geometric parameter related to the wall thickness
AGM	Above Ground Marker
D	Metal loss anomaly depth
EC	Eddy Current
EMAT	Electro Magnetic Acoustic Transducer
ERF	Estimated repair factor
GPS	Global Positioning System
HFEC	High Frequency Eddy Current
ILI	In Line Inspection
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 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 length and the circumferential spacing is less than the smallest anomaly width.

2.4 Nomenclature of features

Features are related to pipeline components or anomalies and can be divided into component features and anomaly features.

Features shall be typed in accordance with Appendix 3a: Report structure, terminology and abbreviations (Column 4, feature type).

- Possible terminology for a component feature type 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 an anomaly feature type is:
  Anomaly.

The type of features shall be further identified in accordance with Appendix 3a: Report structure, terminology and abbreviations (Column 5, feature identification).

- The component features typed as additional metal/material, repair and weld can be further identified as:
  Additional metal/material: Debris magnetic/non-magnetic, 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, Longitudinal / Spiral / not identifiable seam, Seamless (If more features are identified for one weld, then this shall be reported in the column "Comments").
- The 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 Metal loss anomaly 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

To allow the Client to rank the reported anomalies in the pipeline on the basis of a first screening of severity, the Estimated Repair Factor (ERF) shall be calculated. The ERF is defined as:

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

Where P_{safe} is the safe operating pressure as calculated by the latest version of an anomaly assessment method as agreed between Client and Contractor. If not specified otherwise by the Client, method B31 G shall be used. Possible alternative assessment methods are, but not limited to:

- ASME 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-5 (Modified ASME B31 G).
  Pipeline Research Council International (PRCI) contract PR-218-9304, “Continued validation of Rstreng” (Dec. 1996).
- DNV RP-F101.
- Shell 92.
- BS 7910.

2.7 Resolution of measurement parameters

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

Definition	Metric/SI units	Alternative 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 strength (H)	0.1 kA/m	1 Oe (Oersted)
Magnetic flux density (B)	0.1 T (Tesla)	10^3 Gauss
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
Global Position Co-ordinates	0.001 m	10^{-8} ° (Degree)

3. Health and safety

Care for health and safety is essential during any stage of any activity. As intelligent pigging of pipelines typically involves working with pressurized components and potentially explosive and/or flammable environments, adequate procedures must be in place to prevent any harm to personnel, environment or equipment. It is the responsibility of both pipeline operator and (ILI) tool operator to agree on health and safety requirements and procedures and to check if latest and most stringent versions of (local) HSE requirements are met.

ILI operations require a pipeline to be opened and an inspection tool to be loaded/unloaded whereby explosive environments might occur. Special measures to prevent unsafe situations during ILI activities should be taken.

Regulations have been developed to prevent accidents due to explosive environments. Examples of these regulations are the ATEX guideline (ATmosphères EXplosive, European Union) or the NEC 505 (National Electrical Code 505, United States).

Implementation of ATEX, NEC 505 or an equivalent code might be mandatory on the basis of local legislation or can be considered for ILI operations in addition to already applicable standards and procedures. In this specification only ATEX requirements that relate to ILI tools are considered, however it is not claimed that all requirements are covered.

For use of non-electrical equipment in potentially explosives atmospheres, EN13463 or an equivalent standard can be applicable.

3.1 ATEX

The Client shall specify if the ATEX certification will be required and if applicable for the ILI operations, then the following two directives need to be followed.

- ATEX 95* (Equipment Directive 94/9/EC), Design and operation of industrial equipment and protective systems intended for use in potentially explosive atmospheres.
  Note: This directive implies hat the ILI vendor has to assess all potential explosion risks of its equipment and has to design the equipment to this directive.
- ATEX 137* (Workplace Directive 99/92/EC), Organizational requirements for health & safety protection of industrial workers at risk from potentially explosive atmospheres.
  Note: This directive requires that the Pipeline Operator assess the zoning of the Launch/Receive trap workspace through risk assessment and that he is responsible for ensuring that all equipment introduced into these zones is compliant & QA certified against 94/9/EC. Levels of explosion risk zones are:
  Zone 0: Areas with a constantly or long-term dangerous explosive atmosphere caused by gas, vapour or mist.
  Zone 1: Areas where one has to reckon with occasional dangerous explosive atmosphere caused by gas, vapour or mist.

Zone 2: areas where one has to reckon with a dangerous explosive Atmosphere caused by gas, vapour or mist occurring only rarely and then only for a short time

Non-Hazardous Area: Procedure ensures that an explosive atmosphere will NOT occur

ATEX 95 (equipment directive 94/9/EC)
The Client must assess the zone classification of the work environment. For ILI activities in the oil and gas industry it is considered that, unless specific measures are taken, zone 1 is typically applicable. If ATEX certification is required and unless the Client notifies otherwise, it is considered that operating the intelligent pig requires ATEX certification for the following conditions:

- Equipment group II (for use in explosive atmospheres)
- Equipment category 2 (high protection level for use in zone 1 & 2)

ATEX 137 (workplace directive 99/92/EC)
ATEX 137 gives organizational and operational requirements for activities in potentially explosive environments. It is the responsibility of both Client and Contractor to define operating procedures and work instructions to assure safe work environment. These procedures are (except those related to zone classification, see above) considered outside the scope of this document.

In addition to the ATEX requirements, which are only valid for atmospheric conditions, the Client shall specify, whether the contractor shall ensure save operation of ILI equipment under explosive conditions for pressures > 1.1 bar during receiving and launching of tools.

* Latest or superseding version shall be used

3.2 NEC 505

The National Electrical Code 505 is an adoption of ATEX and not further discussed in this specification.

4. Tool specifications

4.1 General tool specifications

The most common tools for metal loss and crack inspection are based on the MFL or “conventional” UT-pulse echo techniques. Geometry tools are available for detecting and sizing of deformations and mapping tools for localization of a pipeline and/or pipeline features. For these techniques detailed tool specifications are requested in the subsequent paragraphs. For metal loss and crack inspection tools that are based on another technology (e.g. EMAT, phased array ultrasonic, EC, HFEC), the given tool specifications can be used as a basis for the level of details required by the Client to perform an evaluation of the proposed system with regards to detection ability and sizing accuracy. If different technologies (e.g. MFL and UT) are combined into one tool, then the specifications shall be provided as if the technologies are applied in a separate tool and additionally a table with the specifications of the multi-technology tool.

The measurement specifications shall include the Tables 2 to 9 where they apply. If not agreed otherwise between Client and Contractor, these specifications can be verified with dig-up results, pull/pump test data or a combination thereof at a confidence level of 95%.

General tool specifications, valid for all tool types:

- Wall thickness range for full performance;
- Speed range for full performance;
- Number and type of defect detection and sizing sensors (or the circumferential sample interval in case of a rotating sensor system);
- Axial sample interval, specify distance or frequency (time) controlled;
- Nominal circumferential centre to centre distance of primary measuring sensors;
- Temperature range;
- Maximum pressure;
- Minimum pressure for operation;
- Minimum bend radius;
- Minimum bend to bend distance;
- Minimum distance between T-openings;
- Minimum internal diameter of straight pipe and bend sections;
- Tool length, weight and number of bodies;
- Differential pressure required to launch and run the tool;
- Maximum length of pipeline that can be inspected in one run (may be coupled to max. operating time and condition of the pipeline;
- Minimum length for launcher;
- Minimum distance between receiver valve and reducer in the receiver;
- Indication of by pass flow in case of tool stuck.

4.2 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 axially 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. If the specifications of more type of tools are requested, then individual tables shall be supplied.

In addition to the general tool specifications, MFL tool specifications shall include:

- Direction of magnetisation (axial/circumferential) and polarity of magnetic field.
- Required minimal magnetic field strength H in kA/m at the inner surface of the pipe to meet the given POD and accuracy.
- The magnetic field strength H in kA/m as function of wall thickness and pig speed, at the inner surface of the pipe.
  Note: in cases where high tool velocity (> 2 m/s) is expected and external defects must be assessed, the Client might request the Contractor to supply the magnetic field strength at the outer pipe surface at the expected velocity. This to check that given POD and accuracy are met for external defects.

- Required minimal induced magnetic flux density B in Tesla in the pipe wall to meet the given POD and accuracy.
- Nominal circumferential distance 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 specifications shall include the Tables 1 to 8 where they apply.

It is recognized that the probability of detection of a feature is highly dependent on several factors such as pipe wall magnetization and signal noise (from sensor mechanical ride, sensor noise, electronic noise, cleanliness etc.). Tables 2 and 3 shall therefore be linked to the operating window of the tool (e.g. pipe wall magnetization range, tool velocity and also to the pipe type (i.e. seamless pipe vs. seam-welded pipe).

If crack detection is possible and 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 orientation limits (angle to pipeline axis) of cracks that can be detected;
- The certainty level for the detection of this minimum crack;
- The accuracy of sizing of crack length and depth;
- The certainty level for the sizing performance.

4.3 UT tool specifications – metal loss detection

In addition to the general tool specifications, UT-metal loss detection tool specification shall include:

- Nominal circumferential spacing of measuring sensors;
- Dimensions of UT transducers and diameter of crystal;
- Frequency of UT signal;
- Stand-off distance of UT transducers;
- Diameter* of UT beam (@ -6 dB) at the inner pipe surface and outer pipe surface.

* Diameter of sound beam where pressure is 6 dB below the pressure at the 0 dB position.

The measurement specification shall include the Tables 1 to 8 where they apply.

4.4 UT tool specifications – crack detection

Ultrasonic technology is often used to detect longitudinal and/or circumferential cracks in pipelines. Conventional ultrasonic tools are based on liquid coupled, shear wave transducers. Currently new developments are coming to the market, which include Phased Array UT (liquid coupling required) and EMAT technology that also work without a liquid coupling.

In addition to the general specifications, UT-crack detection tool specifications shall include, for all technologies:

- Crack depth and length detection threshold;
- The orientation limits (angle to pipeline axis) of cracks that can be detected;
- The certainty level for the detection of this minimum crack;
- The accuracy of sizing of crack length and depth;
- The certainty level for the sizing performance.

Complemented for conventional UT technology with:

- Nominal circumferential spacing of measuring sensors;
- Dimensions of UT transducers;
- Frequency of UT signal;
- Angle of UT signal in steel;
- Direction of angle of UT signal relative to pipe axis (longitudinal direction is 0º, circumferential is 90º).

Complemented for phased array technology with:

- Number of phased array transducers;
- Number and dimensions of active elements within each transducer;
- Frequency of UT signal;
- Range of angles of UT signal that is generated in pipe wall;
- Direction of angle of UT signal relative to pipe axis (longitudinal direction is 0º, circumferential is 90º).

Complemented for the EMAT technology with:

- Number of EMAT transducers (transmitter/receiver);
- Type, mode and frequency of ultrasonic signal generated.

The measurement specification shall include Tables 1 and 5.

4.5 Geometry tool specifications

Geometry tools can be used to detect and size geometrical internal anomalies. High resolution geometry tools can be required to accurately size deformations or internal metal losses to assess the integrity of the pipeline. The specifications below might be extended to obtain detailed information on the anomalies of interest.

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);
- Measurement accuracy (depth, length, width);

- Minimum/maximum ovality measurement dimension;
- Number of sensors 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;
- Presence and number of independent girth weld detection sensors.

* Deformation includes dents, wrinkles, buckles.

The measurement specification shall include Tables 1 (where applicable), 6 and 8.

4.6 Mapping tool specifications

Pipeline mapping tools can be applied as a single inspection tool, but currently units are often attached to an MFL or other inspection tool, whereby the inspection unit has a double functionality. Specific post survey interpretation may also allow detecting and sizing of free spans, landslides etc. The specifications of mapping equipment are quite different and require a specific list.

The geographical location of features shall be expressed in GPS coordinates unless specified otherwise by the Client.

The measurement specification shall include Table 1 (where applicable) and 9.

5. Personnel qualification

The personnel operating the ILI systems and the personnel handling, analyzing and reporting the inspection results shall be qualified and certified according to ANSI/ASNT-ILI-PQ-2005 (or later version/superseding document).

Unless the Client specifies otherwise, key personnel shall meet the following minimum qualifications (ref. ANSI/ASNT-ILI-PQ-2005):

- Team leader during ILI field activities: Level II Tool Operator for the applicable technology.
- Data analysis and reporting: Level II Data Analyst for the applicable technology.
- Review of final Client report: Level III Data Analyst for the applicable technology. The review should include (but not limited to) e.g. a quality check of data analysis and reported results.

A list of personnel that will be deployed for the ILI tool run, data analysis and final report review shall be submitted to the Client.

6. Reporting requirements

The requirements herein may be changed at the Client's request. If more than one tool has been applied (e.g. MFL and Geometry) and/or the functionality of the tools has been combined in one tool (e.g. MFL and Mapping tool), then the information of both tools or units shall be combined in one pipe tally and in one list of anomalies. (see example in Appendix 3b, log distance 11177.467).

The final inspection report (hard & electronic copy) of either a single or combined ILI tool run shall contain the following information and be available within 8 weeks of the ILI run unless agreed otherwise:

- Field report
- Tool operational data
- Tool calibration
- Pipe tally
- List of anomalies
- List of clusters
- Summary and statistical data
- Fully assessed feature sheets
- Anomaly ranking method for ERF
- Detection of AGMs

More details on the required information are given below.

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.

6.1 Field report

The field report shall contain a statement of the Contractor on the quality and findings of all preparatory activities, tool runs and inspection run.

6.2 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:

- Data sheet of used tool(s) with e.g. serial number, software version etc.
- 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 and, in case of ultrasonic pigs, echo loss statistics (see below)
- In case of MFL tools, a plot of the magnetic field strength H in kA/m over the length of the pipeline measured at the inner surface of the pipe.
- Tool operational data statement (see below) that can be used to consider a re-run.

Unless specified otherwise, the formulation for acceptable data loss for magnetic tools shall be:
The maximum acceptable sensor loss (primary sensors) and/or data loss is 3% and continuous loss of data from more than three adjacent sensors or 25 mm circumference (whichever is smallest) is not acceptable.

Unless specified otherwise, the formulation for acceptable data loss for UT tools shall be: The maximum acceptable sensor and/or data loss is 3% and the maximum allowable signal loss due to other reasons (e.g. echo loss) is 5%, whereby continuous loss of data from more than two adjacent transducers or 25 mm circumference (whichever is smallest) is not acceptable.

For all technologies an alternative methodology can be to define data loss based on the required POD of a specific defect like:
The POD of an anomaly with minimum dimensions for a minimum percentage of the pipeline surface and pipeline length. E.g. an anomaly with L≥20 mm, W≥20 mm, d≥20% (or d≥1 mm for UT) in the pipeline shall be detected with a POD≥90% for ≥ 97% of the pipeline surface and ≥ 97% of the pipeline length.

The tool operational data statement shall indicate whether the tool has functioned according to specifications and shall detail all locations of data loss and where the measurement specifications are not met. When the specifications are not met (e.g. due to speed excursions, sensor/data loss), the number and total length of the sections shall be reported with possible changes of accuracies and certainties of the reported results.

6.3 Tool calibration

The Contractor shall provide information regarding the calibration procedure and latest calibration record of the tool. The procedure should give insight in, but not limited to: used calibration features, linepipe material, wall thickness and manufacturing process, tool velocity, date and frequency of calibration. For magnetic tools the calibration information will include the tool speed and the measured magnetic field strength value with the position where it was measured. In addition the Contractor shall supply a definition of which sizing model and revision was used.

It can be considered that, for specific applications, specifications and/or defect geometries, dedicated tool calibration can be performed (e.g. with spare project pipes), followed by a modified interpretation/sizing model.

6.4 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 3a, Report structure. The pipe tally shall contain the following fields in the given sequence (see also Appendix 3b, Report structure, Example pipe tally):

- Log distance;
- Up stream weld distance;
- Joint length;
- Feature type (for terminology, see Column 4 of Appendix 3a, Report structure);
- Feature identification (for terminology, see Column 5 of Appendix 3a, Report structure);
- Anomaly dimension classification (see Figure 2);
- Clock position (see Figure 1);

- Nominal t (of each joint or pipeline component, between girth welds);
- Measured t* (see below);
- Reference t;
- Length of anomaly/feature;
- Width of anomaly/feature;
- d/t in % for MFL and d in mm or inch for UT;
- Surface location: internal (INT), external (EXT), mid-wall (MID) or not applicable (N/A), see Column 14, Appendix 3a, Report structure;
- GPS coordinates of features if geographical tool is used;
- ERF;
- Comments.

* If not specified otherwise by the Client, the average of the wall thickness measurements of undiminished sections is regarded to be representative for the pipe joint/component.

6.5 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 (see also Appendix 3c, Report structure, Example List of Anomalies).

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 3a: 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 Chapter 2.3) and the not-clustered (individual) anomalies. Additionally the individual anomalies forming the reported cluster (see Chapter 2.3) shall be listed in the final inspection report whereby the relation between the anomalies and clusters are indicated (e.g. numbered).

On the Client's request also the location of the deepest point in the metal loss area or clustered area shall be reported.

6.6 List of clusters

The individual anomalies that form clusters (see Chapter 2.3) shall be reported in the list of clusters (see Appendix 3d: Report structure, Example List of Clusters). This list shall be part of the final inspection report whereby the relation between the anomalies and clusters are indicated (e.g. numbered).

6.7 Summary and statistical report

6.7.1 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.

<u>If requested by the Client</u>, the following histograms shall be provided over appropriate section lengths of the pipeline (lengths of appropriate sections to be agreed between Contractor and Client):

- Number of anomalies in sections with depth < 0.4t;
- Number of anomalies in sections with depth 0.4t – <0.6t;
- Number of anomalies in sections with depth 0.6t – <0.8t;
- Number of anomalies in sections with depth ≥0.8t;
- Number of anomalies in sections with ERF 0.8 – <1.0;
- Number of anomalies in 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.

6.7.2 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.

* For applied definition of ovality see Table 6. By agreement between Client and Contractor another definition and/or reporting windows can be specified.

6.8 Fully assessed feature sheets (dig-up sheets)

Unless specified otherwise, fully assessed feature sheets shall be provided for the ten most serious indications. Selection of the most serious 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 five anomalies will be depth based and the other five 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;
- GPS coordinates of anomaly if a mapping tool was used
- Anomaly description and dimensions;
- Internal/external/mid-wall indication.

6.9 Anomaly ranking method for ERF

The estimated repair factor for anomalies shall be reported on the basis of the assessment method indicated in Chapter 2.6.

6.10 Detection of AGMs

AGMs or reference magnets that have been positively identified during the ILI run shall be indicated in the pipe tally. In addition, in the final inspection report the total number of installed AGMs and the number of identified AGMs shall be reported.

Table 1: Identification of features

Feature	**Yes POI>90%**	**No POI<50%**	**May be 50%<=POI<=90%**
Int. / ext. / mid wall discrimination			
Additional metal / material:			
- debris, magnetic			
- debris, non-magnetic			
- touching metal to metal			
- Other			
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 anomaly cluster			
- SCC			
- spalling			
- spiral weld crack			
- spiral weld anomaly			
- wrinkle			
Crack arrestor			
Eccentric pipeline casing			
Change in wall thickness			
CP connection / anode			
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			
- longitudinal weld			
- spiral weld			
- not identifiable seam			
- seamless			

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

	General metal-loss	Pitting	Axial grooving	Circumf. grooving	Pinhole*	Axial slotting*	Circumf. Slotting*
Depth at POD=90%							
Depth sizing accuracy at 80% certainty							
Width sizing accuracy at 80% certainty							
Length sizing accuracy at 80% certainty							

Table 3: Detection and sizing accuracy for metal loss anomalies in weld or HAZ

	General metal-loss	Pitting	Axial grooving	Circumf. grooving	Pinhole*	Axial slotting*	Circumf. Slotting*
Depth at POD=90%							
Depth sizing accuracy at 80% certainty							
Width sizing accuracy at 80% certainty							
Length sizing accuracy at 80% certainty							

Table 4: Length of weld affected area and detection and sizing accuracy for metal loss anomalies in the area

	General metal-loss	Pitting	Axial grooving	Circumf. grooving	Pinhole*	Axial slotting*	Circumf. Slotting*
Length of weld affected area, upstream							
Length of weld affected area, downstream							
Depth at POD=90%							
Depth sizing accuracy at 80% certainty							
Width sizing accuracy at 80% certainty							
Length sizing accuracy at 80% certainty							

* For Tables 2, 3 and 4: Minimum dimensions might be specified.

Table 5: Detection and sizing accuracy for crack or crack-like anomalies.

	Axial crack	Circumf. crack	Spiral crack
Depth at POD=90% of crack with L=25 mm			
Minimum crack opening (mm)			
Depth sizing accuracy at 80% certainty			
Length sizing accuracy at 80% certainty			
Orientation limits (in degrees) for detectability			

Table 6: Detection and sizing accuracy for dents and ovalities

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

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

Table 7: Detection and sizing accuracy in 90º bends.

Minimal bend radius for detection of metal loss anomalies as given in Table 2	D*
Minimal bend radius for sizing accuracy for metal loss anomalies as given in Table 2	D*
Minimal bend radius for detection of crack or crack-like anomalies as given in Table 5	D*
Minimal bend radius for sizing accuracy of crack or crack-like anomalies as given in Table 5	D*

* If the bend radius in the pipeline is smaller than given in the table, then applicable specifications for that bend radius shall additionally be provided in the form of Tables 2 or 5.

Table 8: Location accuracy of features.

Accuracy of distance to upstream girth weld at 90% certainty	
Accuracy of distance from pig trap valve at 90% certainty	
Accuracy of circumferential position at 90% certainty	

Table 9: Horizontal and vertical accuracy of pipeline location as function of marker distance and certainty.

Marker distance (m) (add rows to table if required)	Horizontal accuracy (m) at 80% certainty	Vertical accuracy (m) at 80% certainty
	0.5	0.5
	1.0	1.0
	2.0	2.0

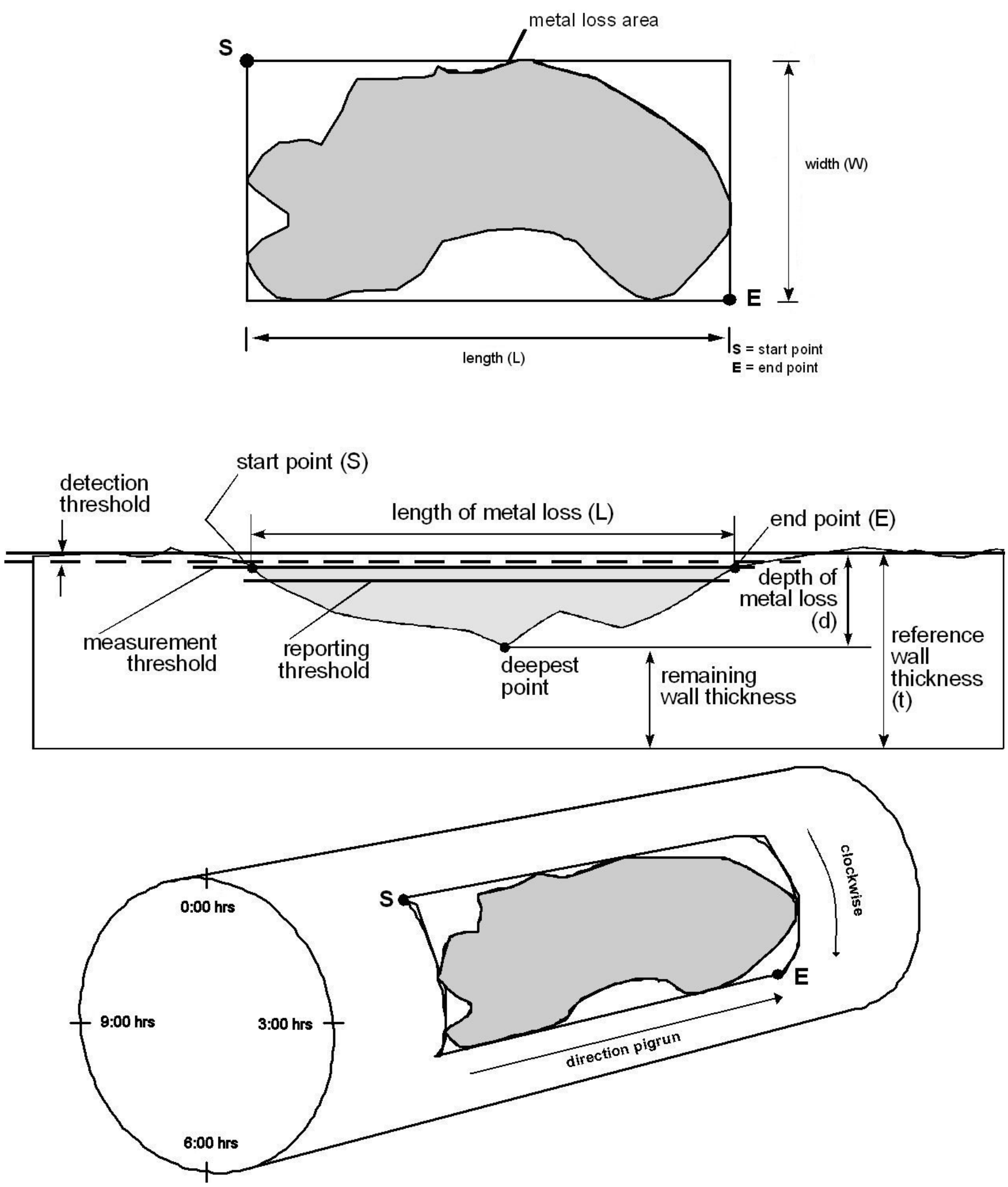
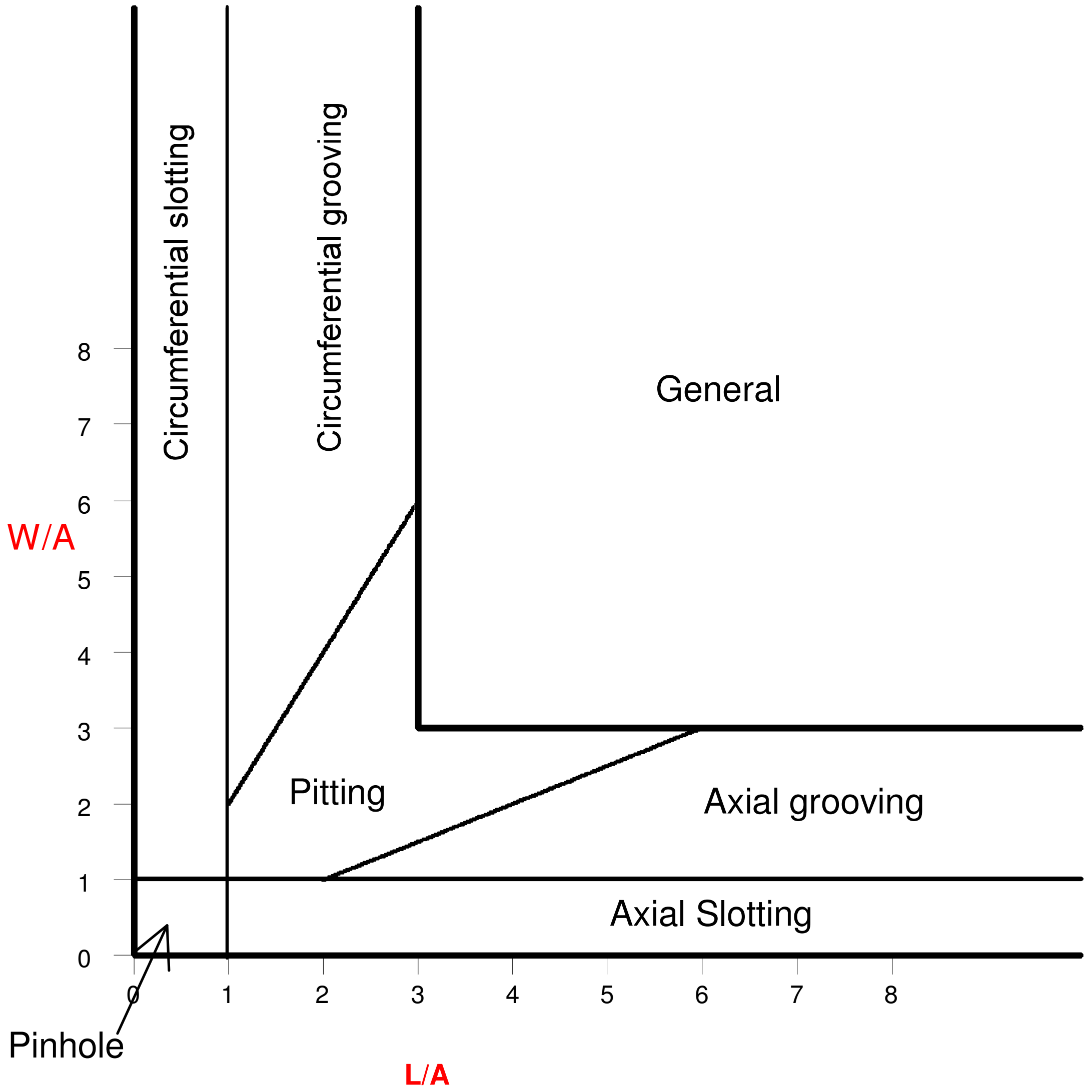


Figure 1: Location and dimensions of metal loss anomaly.



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: Operator's guideline for defining specific details of the POF specifications

Introduction

The POF document "Specifications and requirements for intelligent pig inspection of pipelines" gives an outline of advised specifications for In-Line-Inspection (ILI) of pipelines. The Client (pipeline owner) might adapt certain specification to reflect the Client's specific requirements. For certain aspects of the inspection and/or reporting requirements however, some options are already considered and the document gives the opportunity/requirement to define specific items. This guideline is intended to support the Client by listing the considered optional items in the specifications that can or should be defined prior to sending the specifications to the ILI company.

In addition, in this guideline also some notes and advised specifications are given (*printed in Italic*), like the minimum requirements that are regarded essential for a successful ILI run.

Chapter 2.3 – Geometrical parameters and interaction of anomalies
A default interaction rule is specified, but another rule can be specified if required.

Chapter 2.6 - Estimated Repair Factor
The ASME B31.G methodology is specified as the default assessment method for the ERF calculation, but another methodology can be specified if required.

Note:
- The ASME B31G is commonly used
- The Rstreng method asks for a detailed anomaly profile, which hardly can be provided by present ILI tools. The application of the Rstreng method is more focussed on the detailed measurements based on verification.

Chapter 2.7 – Measurement parameters
The Client shall specify if metric or alternative units shall be used.

Chapter 3.1 – ATEX
The Client shall specify if ATEX certification is required and if so, assess the zone classification.

Chapter 4: Tool specifications
It is requested that the ILI company provides information on anomaly detection and sizing and other measurement capabilities of their tool. Below some typical values that can support the Client in his review of the proposed specifications.

POD of detected anomalies
The POD of a tool is normally taken at 90% and is based on anomalies with reference dimensions as given in the table of Chapter 2.5.

The typical minimal detectable depth of a high resolution MFL tool for general corrosion is 10% t and for pitting defects it is 15% t both with a POD of 90%. For seamless pipes and other category defects other values can apply.

The typical minimal detectable defect depth of a UT tool is 1 to 1.5 mm with a POD of 90%.

Depth, length and width sizing accuracies
The accuracy depends on the anomaly dimension class:
Typical for (high resolution) MFL tools: depth 10-15% t, length and width accuracy 10-20 mm.
Typical for UT tools: depth 0.3 – 0.5 mm, length and width accuracy 10 mm.
For anomaly depth, length and width sizing accuracy, the typical certainty level is 80%.

Accuracy of distance and orientation (clock position) of features:
Typical accuracy of distance to/from marker: 0.25% of distance
Typical accuracy of distance to closest weld: 0.15 m.
Typical accuracy of circumferential position: 10°.

Geometry tool specification, reporting threshold:
The reporting threshold of the geometry tool for dents and ovalities shall be defined.
Typical reporting thresholds: dents: = 2 % pipeline ID and for ovalities = 5% pipeline ID.

Certainty and accuracy of sizing deformations by geometry tool:
The certainties and accuracies of reported dents and ovalities shall be defined.
Typical certainties and accuracies are:

Ovalities:	*ID reduction, accuracy 1% of pipeline ID with certainty = 80%.*
	Length, accuracy 10% of pipeline ID with certainty = 80%.
Dents:	*Depth, accuracy 1% of pipeline ID with certainty = 80%.*
	Length, accuracy 10% pipeline ID with certainty = 80%.
	Width, accuracy 10% pipeline ID with certainty = 80%.

Chapter 4.1 – General tool specifications
ILI companies are requested to supply measurement specification in tables 2 to 9. It is stated that, as a default situation, these specifications can be verified via tests and at a confidence level of 95%. However, it can be agreed to use different defect verification methods and also different confidence levels (e.g. 99%, 90%, 80%).

Chapter 4.2 – MFL tool specifications
ILI companies are requested to supply technical information for review. Below a reference value is given that relates to magnetic properties for MFL inspection.

- *In "Magnetisation as a key parameter of magnetic flux leakage pigs for pipeline inspection" by H.J.M. Jansen, P.B.J. van de Camp and M. Geerdink (Insight Vol 36, September 1994) it is concluded that MFL pigs are least sensitive to error sources (e.g. residual stresses, pressure, remnant magnetization) if the magnetic induction in the pipe wall > 1.8T. The magnetic field strength required to obtain such an induced magnetisation level depends on the type of material, wall thickness, pig speed etc.*

- *NACE International Publication 35100: "In-Line Non-destructive Inspection of Pipelines gives the following typical specifications for high-resolution MFL tools:*
  Minimum magnetic field strength: 10 to 12 kA/m (3 to 3.7 kA/ft)
  Minimum magnetic flux density: 1.7 T.

As the magnetisation level also is a function of the tool velocity (especially at high velocity) and location in the pipe wall (relevant for external corrosion in thick walled pipes), the Client is given the option to request magnetisation data at the outer pipe surface for the applicable tool velocity.

Chapter 4.6 - Mapping tool specifications
Geographical locations shall be reported in GPS coordinates by default, but another method can be specified if required.

Chapter 5 – Personnel qualification
Minimum requirements for qualifications of key personnel are given but can be specified otherwise by the Client.

Chapter 6 – Reporting requirements
The typical contents of the final inspection is given and the maximum time frame for the availability of the final inspection report is stated to be 8 weeks after the ILI run. This time frame is regarded a typical and acceptable period, but a different time frame and different report contents can be agreed between parties.

Chapter 6.2 - Tool operational data
By default, the reporting threshold is specified at 90% POD, but can be specified otherwise.

Note: the reporting threshold for metal loss corrosion defects is typically 10% t and normally taken at 90% POD. For special detailed information (e.g. corrosion growth calculation) 5% and for inspection special focussed on FFP or detection of special threats: 15 or 20%.

A default formulation for acceptable data loss is specified, but another methodology can be specified if required.

Note: For sensor and/or data loss of magnetic and UT tools two possibilities are given. Other formulation of maximum data/sensor loss might be more applicable for specific situations.

Chapter 6.4. – Pipe tally
The standard definition for average pipe wall thickness is stated as representative for the pipe joint/component, but the client can specify another definition.

Chapter 6.7.1 - Summary and statistical report of metal loss tools
Histograms are requested. The appropriate length of pipeline sections shall be defined and agreed.

Chapter 6.7.2 Summary and statistical report of geometry tools
The definition of ovality is specified, but can be changed by agreement.

Chapter 6.8 Fully assessed feature sheets
Two default criteria are given for the provision of feature sheets. The criteria can be specified differently if required.

Appendix 2: ILI companies approached for comments to the draft version of these specifications

COMPANY	COUNTRY	WEBSITE
3P Services	Germany	www.3p-services.com
A. Hak Industrial Services	Netherlands	www.a-hak-is.com
ApplusRTD	Netherlands	www.applusrtd.com
Baker Hughes (CPIG)	Canada	www.bakerhughes.com
BJ Pipeline Inspection Services	Canada	www.bjservices.com
General Electric (PII)	United Kingdom	www.piigroup.com
Linscan	United Arab Emirates	www.linscaninspection.com
NDT Systems & Services AG	Germany	www.ndt-ag.de
Rosen	Germany	www.Roseninspection.net
T.D. Williamson (Magpie)	USA	www.magpiesystems.com
Weatherford (NGKS)	USA	www.weatherford.com

Appendix 3a: Report structure, terminology and abbreviations

Column no.	Column title	Unit	Prescribed terminology	Abbreviation	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	 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	

			- Spiral weld anomaly - Wrinkle - 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 - Longitudinal seam - Spiral seam - Not identifiable seam - Seamless	SWAN WRIN OTHE WSLB/WSLE CSLB/CSLE WDPB/WDPE COTB/COTE OTHB/OTHE BENB/BENE CHDI CHWT ADTA LOSE SPSE NISE SMLS	 No abbreviation for all welds different from welds 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		- Internal - External - Mid wall - Not applicable	INT EXT MID N/A	Location of anomaly on the pipeline: internal, external, mid wall or Not Applicable
15	ERF				
16	Comments	-	-		-

Appendix 3b: 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)	Measured/ Reference t (mm)	Length (mm)	Width (mm)	d (peak) % (MFL) mm (UT)	d (mean) % (MFL) mm (UT)	Surface loc.	GPS	ERF	Comments
11158.682	-	15.38	Weld (WELD)	Longitudinal seam (LOSE)	-	-	14.3	14.8-	-	-	-	-	-		-	-
11161.334	2.65	-	Above Ground Marker (AGM)	-	-	-	14.3	14.8	-	-	-	-	-		-	AGM nr. 6
11163.581	4.90	-	Anomaly (ANOM)	Gouging (GOUG)	CIGR	10:28	14.3	14.8	23	254	28	16	EXT		-	-
11165.903	7.22	-	Anomaly (ANOM)	Corrosion cluster (COCL)	GENE	5:12	14.3	14.8-	392	188	17	11	EXT		0.94	-
11174.067	-	12.16	Weld (WELD)	Change in wall thickness (CHWT)	-	-	12.4	12.9	-	-	-	-	-		-	-
11175.285	1.22	-	Anomaly (ANOM)	Dent (DENT)	-	0:18	12.4	13.0	-	-	-	-	-		-	2.5 % Dent depth
11177.467	3.40	-	Anomaly (ANOM)	Dent with metal Loss (DEML)	-	12:08	12.4	13.0	112	7	16	9	-		-	5.5 % Dent depth
1178.969	4.90	-	Anomaly (ANOM)	Pipe mill anomaly cluster (MIAC)	GENE	10:15	12.4	13.0	401	889	25	12	INT		-	-
11183.152	9.09	-	Anomaly (ANOM)	Pipe mill anomaly (MIAN)	CIGR	6:12	12.4	13.0	17	55	15	9	EXT		-	-
11183.324	9.26	-	Casing begin (CASB)	-	-	-	12.4	13.0	-	-	-	-	-		-	Mainstreet
11185.968	11.90	-	Casing end (CASE)	-	-	-	12.4	13.0	-	-	-	-	-		-	-
11186.222	-	12.48	Weld (WELD)	Longitudinal seam (LOSE)	-	-	12.4	13.0	-	-	-	-	-		-	-
11187.978	1.75	-	Anomaly (ANOM)	Longitudinal weld anomaly (LWAN)	PITT	2:09	12.4	12.9	39	26	15	8	EXT		-	-
11198.701	-	12.56	Weld (WELD)	Change in wall thickness (CHWT)	-	-	11.2	11.9	-	-	-	-	-		-	Seamless (SMLS)
11198.701	0.00	-	Anomaly (ANOM)	Girth weld anomaly (GWAN	CIGR	4:06	11.2	11.9	14	131	10	6	N/A		-	-
111202.352	3.65	-	Anomaly (ANOM)	Grinding (GRIN)	CIGR	6:6	11.2	11.9	16	43	16	4	EXT		-	-
11203.013	4.31	-	Additional metal / material (ADME)	Touching metal to metal (TMTM)	-	1:46	11.2	11.9	-	-	-	-	-		-	-
11211.267	-	3.00	Weld (WELD)	Spiral seam (SPSE)	-	-	20.4		-	-	-	-	-		-	Installation S114-01
11212.769	1.50		Tee (TEE)	-	-	3:00	20.4		-	-	-	-	-		-	Installation S114-01
11214.263	-	3.50	Weld (WELD)	Spiral seam (SPSE)	-	-	30.8		-	-	-	-	-		-	Installation S114-01
11216.015	1.75		Valve (VALV)	-	-	12:00	30.8		-	-	-	-	-		-	Installation S1140
11217.767	-	2.20	Weld (WELD)	Bend begin (BENB)	-	-	18.2	-	-	-	-	-	-		-	Installation S1140

Appendix 3b: 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)	Measured/ Reference t (mm)	Length (mm)	Width (mm)	d (peak) % (MFL) mm (UT)	d (mean) % (MFL) mm (UT)	Surface loc.	GPS	ERF	Comments
11219.965	-	12.54	Weld (WELD)	Bend end (BENE)	-	-	11.2	11.9	-	-	-	-	-		-	Installation S1140
11232.502	-	13.02	Weld (WELD)	Not identifiable seam (NISE)	-	-	11.2	11.9	-	-	-	-	-		-	-
11232.758	0.25	-	Anomaly (ANOM)	Corrosion (CORR)	PITT	6:11	11.2	11.9	10	17	17	11	EXT		0.91	-
11245.521	-	12.30	Weld (WELD)	Not identifiable seam (NISE)	-	-	11.2	11.9	-	-	-	-	-		-	-
11257.822	-	11.20	Weld (WELD)	Bend begin (BENB)	-	-	11.2	12.7	-	-	-	-	-		-	-
11269.026	-	12.04	Weld (WELD)	Bend end (BENE)	-	-	11.2	12.7	-	-	-	-	-		-	-
11281.064	-	12.09	Weld (WELD)	Not identifiable seam (NISE)	-	-	11.2	11.9	-	-	-	-	-		-	-
11292.613	11.55	-	Repair (REPA)	Welded sleeve begin (WSLB)	-	-	11.2	11.9	-	-	-	-	-		-	-
11293.062	12.00	-	Anomaly (ANOM)	Corrosion (CORR)	CIGR	7:09	11.2	11.9	23	65	13	11	EXT		0.91	-
11293.154	-	12.54	Weld (WELD)	Not identifiable seam (NISE)	-	-	11.2	11.9	-	-	-	-	-		-	-
11293.311	0.16	-	Anomaly (ANOM)	Corrosion (CORR)	AXGR	6:23	11.2	11.9	126	16	21	12	EXT		0.94	-
11293.383	0.23	-	Anomaly (ANOM)	Corrosion (CORR)	GENE	8:12	11.2	11.9	36	40	17	12	EXT		0.91	-
11293.670	0.52	-	Repair (REPA)	Welded sleeve end (WSLE)	-	-	11.2	11.9	-	-	-	-	-		-	-
11305.697	-	12.54	Weld (WELD)	Not identifiable seam (NISE)	-	-	11.2	11.9	-	-	-	-	-		-	-

Appendix 3c: 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)	Measured / Reference t (mm	Length (mm)	Width (mm)	d (peak) % (MFL) mm (UT)	d (mean) % (MFL) mm (UT)	Surface loc.	GPS	ERF	Comments
11163.581	4.90	-	Anomaly (ANOM)	Gouging (GOUG)	CIGR	10:28	14.3	14.8	23	254	28	16	EXT		-	-
11165.903	7.22	-	Anomaly (ANOM)	Corrosion cluster (COCL)	GENE	5:12	14.3	14.8	392	188	17	11	EXT		0.94	-
11175.285	1.22	-	Anomaly (ANOM)	Dent (DENT)	-	0:17	12.4	13.0	-	-	-	-	-		-	2.5 % Dent depth
11177.467	3.40	-	Anomaly (ANOM)	Dent with metal Loss (DEML)	-	12:01	12.4	13.0	112	7	16	9	-		-	5.5 % Dent depth
11178.969	4.90	-	Anomaly (ANOM)	Corrosion cluster (COCL)	GENE	10:15	12.4	13.0	401	889	25	12	INT		-	-
11183.152	9.09	-	Anomaly (ANOM)	Pipe mill anomaly (MIAN)	CIGR	6:13	12.4	13.0	17	55	15	9	EXT		-	-
11187.978	1.75	-	Anomaly (ANOM)	Longitudinal weld anomaly (LWAN)	PITT	2:09	12.4	12.9	39	26	15	8	EXT		-	-
11198.701	0.00	-	Anomaly (ANOM)	Girth weld anomaly (GWAN)	CIGR	4:08	11.2	11.9	14	131	10	6	N/A		-	-
111202.352	3.65	-	Anomaly (ANOM)	Grinding (GRIN)	CIGR	6:31	11.2	11.9	16	43	16	4	EXT		-	-
11232.758	0.25	-	Anomaly (ANOM)	Corrosion (CORR)	PITT	6:11	11.2	11.9	10	17	17	11	EXT		0.91	-
11293.062	12.00	-	Anomaly (ANOM)	Corrosion (CORR)	CIGR	7:08	11.2	11.9	23	65	13	11	EXT		0.91	-
11293.311	0.16	-	Anomaly (ANOM)	Pipe mill anomaly Cluster (MIAC)	AXGR	6:04	11.2	11.9	126	16	21	12	EXT		0.94	-
11295.383	0.23	-	Anomaly (ANOM)	Corrosion (CORR)	GENE	8:19	11.2	11.9	36	40	17	12	EXT		0.91	-

Appendix 3d: Report structure, example list of clusters

Log distance (m)	Up weld dist. (m)	Anomaly Feature identification	Clock position h:min	Nominal t (mm)	Measured or Reference t (mm)	Length (mm)	Width (mm)	d (peak) % (MFL) mm (UT)	d (mean) % (MFL) mm (UT)	Surface location	Comments
11165.903	4.900	Corrosion cluster 4	10:28	14.3		345	240	28	16	EXT	-
11165.903	4.900	Corrosion	10:57	14.3		39	178	17	11	EXT	-
11166.013	5. 013	Corrosion	10:28	14.3		232	180	28	18	EXT	
11178.969	3.400	Corrosion cluster 5	1:01	12.4		601	389	26	18	EXT	
11178.969	3.400	corrosion	1:50	12.4		306	267	26	10	EXT	-
11179.303	3.642	corrosion	2:10	12.4		167	80	16	12	EXT	-
11179.562	5.40	corrosion	3:31	12.4		200	229	13	9	EXT	-
11179.969	3.908	corrosion	1:01	12.4		35	100	18	11	EXT	-
11293.315	0.162	Pipe mill anomaly cluster 4	6:04	11.2		126	160	21	12	EXT	-
11293.315	0.162	pipe mill anomaly	7:09	11.2		90	39	16	11	EXT	-
11293.369	0.216	pipe mill anomaly	6:04	11.2		52	100	19	12	EXT	
11293.375	0.222	pipe mill anomaly	7:04	11.2		66	89	21	18	EXT	