

In-line Inspection Systems Qualification

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Introduction

This standard provides requirements for qualification of in-line inspection systems used in gas and hazardous liquid pipelines. The standard facilitates the following.

- a) Inspection service providers make clear, uniform, and verifiable statements describing in-line inspection system performance.
- b) Pipeline operators select an inspection system suitable for the conditions under which the inspection will be conducted. This includes, but is not limited to, the pipeline material characteristics, pipeline operating conditions, and types of anomalies expected to be detected and characterized.
- c) The in-line inspection system operates properly under the conditions specified.
- d) Inspection procedures are followed before, during, and after the inspection.
- e) Anomalies are described using a common nomenclature, as described in this standard and in referenced documents.
- f) The reported data and inspection results provide the expected accuracy and quality in a consistent format.

Users of this standard should be aware that further or differing requirements may be needed for some applications. Nothing in this standard is intended to inhibit the use of inspection systems or engineering solutions that are not covered by the standard. This may be particularly applicable where there is innovative developing technology. For these technologies, this standard may be used, provided applicable variations from the standard are identified and documented.

Personnel and equipment used to perform in-line inspections and analyze the results shall be qualified according to this standard and its companions, ASNT ILI-PQ, *In-line Inspection Personnel Qualification and Certification* and NACE SP0102, *In-line Inspection of Pipelines*. This standard is an umbrella document covering all aspects of in-line inspection systems, incorporating the requirements of ASNT ILI-PQ and NACE SP0102 by reference.

This standard is not technology specific. It accommodates present and future technologies used for in-line inspection systems. This standard is performance based and provides requirements for qualification processes. It does not, however, define how to meet those requirements. This standard defines the documentation of processes for in-line inspection system qualifications. One objective of this standard is to foster continual improvement in the quality and accuracy of in-line inspections. Wherever possible, this standard utilizes existing terms and definitions from other applicable standards. Section 3 provides definitions of terms.

The use of an in-line inspection system to manage the integrity of pipelines requires close cooperation and interaction between the provider of the inspection service (service provider) and the beneficiary of the service (operator). This standard provides requirements that will enable service providers and operators to clearly define the areas of cooperation required and thus ensure the satisfactory outcome of the inspection process. Whereas service providers have the responsibility to identify in-line inspection system capabilities, their proper use, and application, operators bear the ultimate responsibility to:

- a) identify specific risks (threats) to be investigated;
- b) choose the proper inspection technology;
- c) maintain operating conditions within performance specification limits;
- d) confirm inspection results.

Following the standard provides a consistent means of assessing, using, and validating results from in-line inspection systems such that acceptable inspection results are obtained.

In-line Inspection Systems Qualification

1 Scope

This standard covers the qualification, selection, reporting, verification, validation, and use of in-line inspection (ILI) systems for onshore and offshore steel gas and hazardous liquid pipelines. This includes, but is not limited to, tethered, self-propelled, or free-flowing systems for detecting metal loss, cracks, mechanical damage, pipeline geometries, and pipeline location or mapping. The standard applies to both existing and developing technologies.

This standard is an umbrella document that provides performance-based requirements for ILI systems, including procedures, personnel, equipment, and associated software.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Recommended Practice 1176, *Assessment and Management of Cracking in Pipelines*

API Recommended Practice 1183, *Assessment and Management of Pipeline Dents*

ASNT ILI-PQ ¹, *In-line Inspection Personnel Qualification and Certification*

NACE SP0102 ², *In-line Inspection of Pipelines*

CEPA ³, *Metal Loss Inline Inspection Tool Validation Guidance Document*, First Edition

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

aboveground marker

AGM

A spatial reference point that is identifiable as a distinct feature in the ILI.

NOTE This may also include the ability to detect and record the passage of an ILI tool.

3.1.2

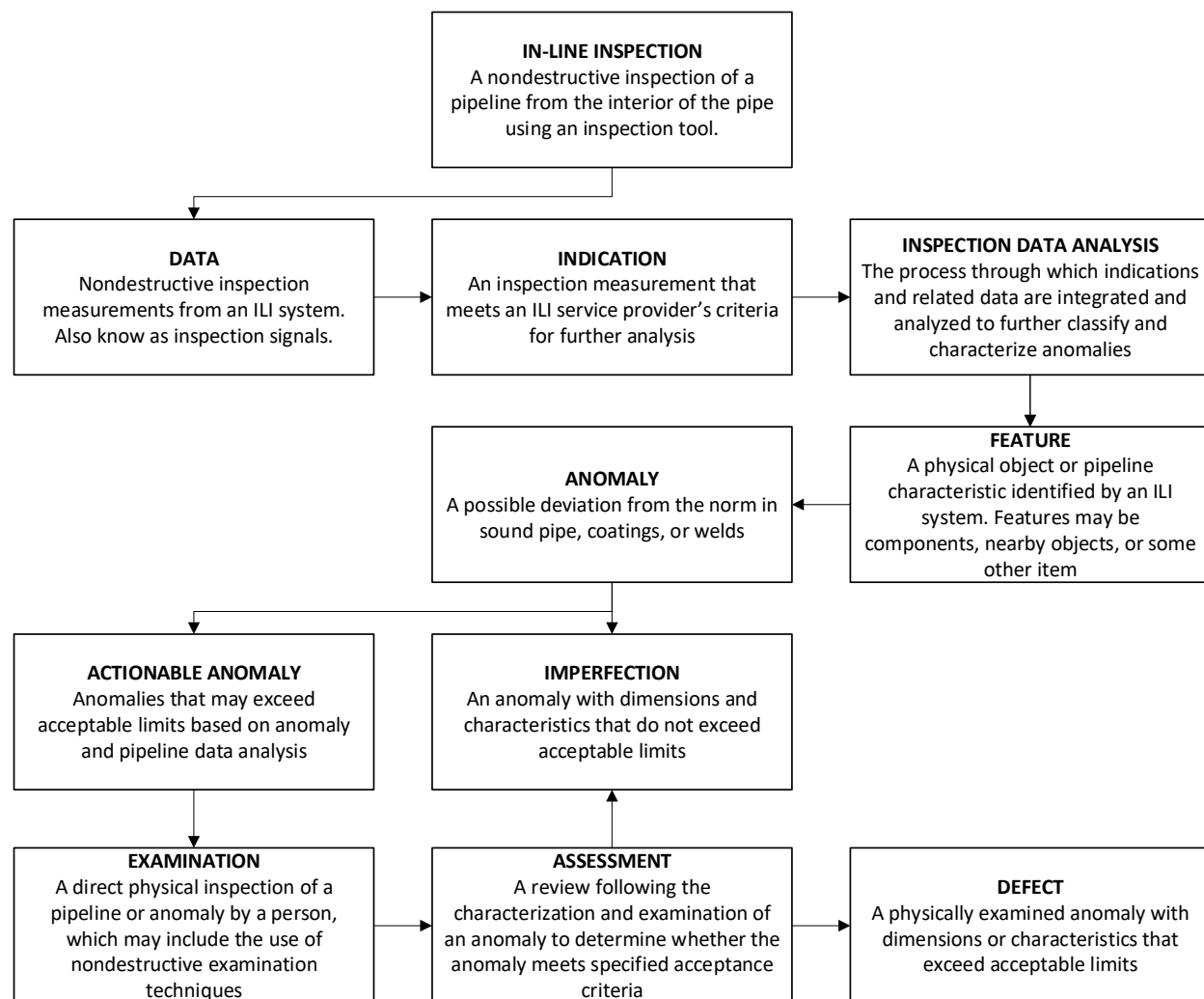
actionable anomaly

An anomaly that may exceed acceptable limits based on the operator's anomaly and pipeline data analysis (see Figure 1).

¹ American Society for Nondestructive Testing, 1711 Arlingate Lane, Columbus, Ohio 43228, <https://www.asnt.org>.

² NACE International (now Association for Materials Protection and Performance), 15835 Park Ten Place, Houston, Texas 77084, <https://ampp.org>.

³ Canadian Energy Pipeline Association, 1110, 505 – 3rd Street SW, Calgary, Alberta T2P 3E6, Canada, <https://cepa.com/en>.



NOTE Not all steps are required, and the order of steps may differ depending on operator requirements.

Figure 1—Inspection Terminology

3.1.3 anomaly

Possible unexplained deviations from the norm in sound pipe material, coatings, or welds.

See also “imperfection,” “defect,” and “feature” (see Figure 1).

3.1.4 appurtenance

A component that is attached to the pipeline (e.g. valve, tee, casing, instrument connection).

3.1.5 assessment

Analytical process by which a feature, an anomaly, or an imperfection is evaluated, classified, or dismissed.

3.1.6 bend

A physical pipe configuration that changes pipeline direction.

3.1.7**buckle**

A deformation of the pipe wall caused by lateral instability under longitudinal compressive stresses imposed by axial or bending loading acting on the pipe cross section.

NOTE See ASME B31.4 or CSA Z662 for further information on buckles.

3.1.8**calibration dig**

An exploratory excavation to compare findings of an ILI system to actual conditions with the purpose of improving data analysis.

See also “validation measurement.”

3.1.9**caliper tool**

A type of tool used to measure the internal diameter of a pipeline.

3.1.10**casing**

A cylinder surrounding the pipeline, installed for the purpose of protecting the pipeline from external damage.

3.1.11**certainty**

The probability that a reported anomaly characteristic is within a stated tolerance.

NOTE This can also be referred to as a proportion or coverage probability.

3.1.12**certification**

A written testimony of qualification.

3.1.13**chainage**

Cumulative pipeline distance usually measured on the surface from a specific point of origin.

NOTE This chainage reference may contain multiple discontinuities within the extent of a single ILI run.

3.1.14**characteristic**

Any physical descriptor of a pipeline (e.g. grade, wall thickness, manufacturing process) or an anomaly (e.g. type, size, shape).

3.1.15**characterize**

To assign characteristics to a pipeline anomaly or feature, based on its classification.

3.1.16**classify**

To identify the cause of an inspection indication (e.g. anomaly, nonrelevant indication, feature, component, or type of imperfection/defect).

3.1.17**cluster**

Two or more adjacent metal loss features in the wall of the pipe or weld that may interact based on interaction criteria.

3.1.18**cold work**

Permanent strain in a metal accompanied by strain hardening.

3.1.19**component**

Any physical part of the pipeline, other than line pipe, including but not limited to valves, welds, tees, flanges, fittings, taps, branch connections, outlets, supports, and anchors.

3.1.20**confidence level**

The frequency at which the sampling process used to construct a statistical interval, if repeated many times over, would yield an interval that covers the true value of the unknown quantity.

3.1.21**corrosion**

The volumetric deterioration resulting in metal loss through a reaction with its environment.

3.1.22**crack**

A fracture type discontinuity characterized by a sharp tip and high ratio of length to width (i.e. opening displacement).

3.1.23**data analysis**

The evaluation process through which inspection indications are classified and characterized.

3.1.24**defect**

A physically examined anomaly with dimensions or characteristics that exceed acceptable limits.

See also “imperfection,” “anomaly,” and “feature” (see Figure 1).

3.1.25**deformation**

A change in shape, such as a bend, buckle, dent, ovality, ripple, wrinkle, or any other change that affects the roundness of the pipe's cross section or straightness of the pipe.

3.1.26**deformation tool****geometry tool**

An instrumented ILI tool designed to measure deformations in the pipe.

3.1.27**dent**

A local change in piping surface contour caused by an external force such as mechanical impact or rock impact.

3.1.28**detect**

To sense or obtain a measurable indication from a feature.

3.1.29**detection threshold**

A characteristic dimension or dimensions of an anomaly that must be exceeded to achieve a stated probability of detection (POD).

See also “measurement threshold” and “reporting threshold.”

3.1.30**electric resistance welding**

A welding process used in the manufacturing of pipe.

3.1.31**electromagnetic acoustic transducer**

A type of transducer that generates ultrasound in steel pipe without a liquid couplant using magnets and coils for inspection of the pipe.

3.1.32**essential variables**

The common set of characteristics or analysis steps for a family (series) of ILI tools that may be covered within one performance specification.

3.1.33**evaluation**

A review, following the characterization and examination of an anomaly, to determine whether the anomaly meets specified acceptance criteria.

3.1.34**examination**

A direct physical inspection of an anomaly by a person, which may include the use of nondestructive examination (NDE) techniques.

3.1.35**failure pressure ratio****FPR**

Ratio of the ERP to the maximum pressure expected during service, i.e. the ratio of the calculated failure pressure of an anomaly to the maximum operating pressure (MOP) at the location of the anomaly, i.e. $FPR = ERP/MOP$.

NOTE In the context of an FPR in an ILI report, the MOP used would typically be the MAOP.

3.1.36**feature**

Any physical object detected by an ILI system.

See also “imperfection,” “anomaly,” and “defect” (see Figure 1).

NOTE Features may be anomalies, components, nearby metallic objects, welds, appurtenances, or some other item.

3.1.37**gauging pig**

A utility pig mounted with a flexible metal plate or plates to gauge the internal diameter of the pipeline.

NOTE Pipe bore restrictions less than the plate diameter or short radius bends will permanently deflect the plate material.

3.1.38**girth weld**

A complete circumferential butt weld joining pipe or components.

3.1.39**gouge**

Elongated grooves or cavities usually caused by mechanical removal of metal.

See also “cold work.”

3.1.40**hard spot**

A localized increase in hardness through the thickness of a pipe, produced during hot rolling of a steel plate as a result of localized quenching.

3.1.41**hook crack**

Metal separation resulting from imperfections parallel to the surface of the plate that are turned toward the internal or external surface during welding.

3.1.42**identification**

Generally understood to be the delineation of the type of feature; this may be extended to include secondary characterization of an anomaly where mitigation decisions hinge around such characterization.

3.1.43**imperfection**

Flaw or other discontinuity noted during inspection that passes acceptance criteria during an engineering and inspection analysis.

See also “feature,” “anomaly,” and “defect” (see Figure 1).

3.1.44**indication**

A finding from nondestructive testing, inspection technique, or a signal from an ILI system.

NOTE An indication from an ILI system may be further classified or characterized as an anomaly, imperfection, or component (see Figure 1).

3.1.45**inertial tool**

A type of ILI tool used to map the centerline of a pipeline using sensors that respond to inertial changes.

NOTE A component of an inertial tool is the inertial measurement unit.

See also “mapping tool.”

3.1.46**in-line inspection****ILI**

An inspection of a pipeline from the interior of the pipe using an inspection tool; also called intelligent or smart pigging.

NOTE This definition includes tethered and self-propelled inspection tools.

3.1.47**in-line inspection system**

An inspection tool and the associated hardware, software, procedures, and personnel required for performing and interpreting the results of an ILI.

3.1.48**in-line inspection technology**

A class of inspection methodologies [i.e. electromagnetic acoustic transducer, magnetic flux leakage (MFL), ultrasonic, caliper, etc.] used in the performance of an ILI.

3.1.49**in-line inspection tool**

An instrumented device or vehicle that uses a nondestructive testing technique to inspect the pipeline from the inside to detect features along a pipeline; also known as an intelligent pig or smart pig.

3.1.50**inspection**

The use of a nondestructive testing technique.

3.1.51**interaction criteria**

A spacing criterion among anomalies that establishes when closely spaced anomalies should also be reported as a cluster.

3.1.52**lamination**

A planar discontinuity parallel or near parallel to the pipe wall.

3.1.53**launcher**

A device used to insert an ILI tool into a pressurized pipeline; may be referred to as a pig trap or scraper trap.

3.1.54**line proving tool**

An ILI system used to verify a pipeline can be safely inspected with another ILI inspection tool.

3.1.55**magnetic flux leakage****MFL**

A type of ILI technology in which a magnetic field is induced in the pipe wall between two poles of a magnet and changes to the distribution of the magnetic flux caused by anomalies are detected.

3.1.56**magnetic particle inspection**

An NDE technique for locating surface flaws in steel using fine magnetic particles and magnetic fields.

3.1.57**management of change**

A process that systematically recognizes changes of a technical, physical, procedural, or organizational nature and communicates them to the appropriate parties.

3.1.58**mapping tool**

An ILI tool that uses inertial sensing or other technology to collect data that can be analyzed to produce an elevation and plan view of the pipeline route.

See also "inertial tool."

3.1.59**maximum allowable operating pressure****MAOP**

The maximum sustained operating pressure that is permissible for a pipeline segment by the applicable regulation.

3.1.60**measurement threshold**

A dimension or dimensions above which an anomaly measurement can be made.

See also "detection threshold" and "reporting threshold."

3.1.61**mechanical damage**

A generic term used to describe combinations of dents, gouges, and/or cold work caused by the application of external forces.

3.1.62**metal loss**

Any volumetric pipe anomaly in which metal has been removed; metal loss is usually due to corrosion or gouging.

3.1.63**nominal wall thickness**

The wall thickness specified for the manufacture of the pipe.

NOTE Actual wall thickness may vary within a range, typically as permitted by the pipe manufacturing standard/specification.

3.1.64**nondestructive testing**

A process that involves the inspection, testing or assessment of materials, components, and assemblies for materials' discontinuities and properties without further impairing or destroying the part's serviceability.

3.1.65**operator**

A person or organization that owns or operates pipeline facilities.

3.1.66**ovality**

Out of roundness relative to the nominal circular shape, i.e. egg shaped or broadly elliptical.

3.1.67**performance specification**

A written set of statements that define the capabilities of an ILI system to detect, classify (identify), and characterize features.

3.1.68**pig**

A generic term signifying any independent, self-contained, or tethered device, tool, or vehicle that moves through the interior of the pipeline for inspecting, dimensioning, or cleaning; may or may not be an ILI tool.

3.1.69**pipeline**

A continuous part of a pipeline facility used to transport a hazardous liquid or gas; includes pipe, valves, and other appurtenances attached to pipe.

3.1.70**pipeline coordinates**

Location coordinates of the course that a pipeline follows as given in a standard geographic coordinate system.

3.1.71**pipeline system**

All portions of the physical facilities through which gas, oil, or product moves during transportation.

NOTE This includes pipe, valves, and other appurtenances attached to the pipe, compressor units, pumping units, metering stations, regulator stations, delivery stations, breakout tanks, holders, and other fabricated assemblies.

3.1.72**pitting**

Localized corrosion of a metal surface that is confined to small areas and takes the form of cavities called pits.

3.1.73**probability of detection****POD**

The probability of a feature being detected by an ILI tool.

3.1.74**probability of false call**

The probability of a nonexisting feature being reported as a feature.

3.1.75**probability of false reporting**

The probability of a feature being incorrectly categorized as specific feature of interest.

3.1.76**probability of identification****POI**

The probability that the type of an anomaly or other feature, once detected, will be correctly classified (e.g. as metal loss, dent, etc.).

3.1.77**probability of reporting****POR**

The probability that a feature, typically an anomaly, of a particular type and severity, will be both detected and correctly classified (e.g. as a crack) in the features reported.

3.1.78**qualification (personnel)**

The process of demonstrating skill and knowledge, along with documented training and experience required for personnel to properly perform the duties of a specific job.

3.1.79**qualification (system)**

The process of validating, through tests and analysis, the performance specifications of an ILI system.

3.1.80**quality control****QC**

Process of ensuring that the task was performed as intended.

3.1.81**receiver**

A pipeline facility used for removing a pig from a pressurized pipeline; may be referred to as trap or pig trap or scraper trap.

3.1.82**reference point**

A well-documented point on the pipe or right of way that serves as a measurement point for location of features.

3.1.83**reporting threshold**

A parameter that defines whether an anomaly will be reported.

NOTE The parameter may be a limiting value on the depth, width, or length of the anomaly or feature.

3.1.84**ripple**

A smooth wrinkle or bulge visible on the outside wall of the pipe.

See also “buckle” and “wrinkle.”

3.1.85**run performance**

Establishing accuracy of the tool as run.

See “performance specification.”

3.1.86**seam weld**

The longitudinal or spiral weld in pipe, which is made in the pipe mill.

3.1.87**seamless**

Pipe made without a seam weld.

3.1.88**sizing accuracy**

The accuracy with which an anomaly dimension or characteristic is reported.

NOTE Typically, accuracy is expressed by a tolerance and a certainty. As an example, depth sizing accuracy for metal loss is commonly expressed as $\pm 10\%$ of the wall thickness (the tolerance) 80 % of the time (the certainty).

3.1.89**specified minimum yield strength****SMYS**

The minimum yield strength prescribed by the specification under which pipe is purchased from the manufacturer.

3.1.90**spiral weld**

A longitudinal double submerged arc welding that traverses helically around the pipe. A welding process used in the manufacture of pipe.

3.1.91**stress**

Tensile, shear, or compressive force per unit area.

3.1.92**stress corrosion cracking****SCC**

A form of cracking produced by the combined application of tensile stress (residual or applied), a corrosive environment, and steel that is susceptible to SCC.

3.1.93**tolerance**

The accuracy with which an anomaly dimension or characteristic is reported with a specified certainty.

3.1.94**trap**

A pipeline facility for launching or receiving tools and pigs.

See “launcher” and “receiver.”

3.1.95**ultrasonic testing**

A type of inspection technology that uses ultrasound for inspecting pipe.

3.1.96**validation**

The act of checking ILI results against empirical evidence, such as a field measurement.

NOTE This speaks to accuracy of the tool results.

3.1.97**validation measurement**

A reference measurement independent of the ILI made to assess the accuracy of the reported results of an ILI.

See “calibration dig.”

3.1.98**verification**

The act of checking that the ILI system processes were performed as intended.

NOTE This provides an indication of the expected effectiveness of the tool performance.

3.1.99**wrinkle**

A smooth and localized undulation visible on the outside wall of the pipe.

See also “ripple.”

3.1.100**wrinkle bend**

A field bend that contains smooth and localized wrinkles on the inner radius of the bend.

3.2 Acronyms and Abbreviations

AGM	aboveground marker
DQA	data quality assessment
HCA	high consequence area
ILI	in-line inspection
MFL	magnetic flux leakage
MOP	maximum operating pressure
NDE	nondestructive examination
POD	probability of detection
POFR	probability of false reporting
POI	probability of identification
POR	probability of reporting
QC	quality control
RCA	root cause analysis
SCC	stress corrosion cracking

4 Systems Qualification Process

4.1 General

Section 4 describes the processes and personnel qualification requirements for the activities involved in using an ILI system. The requirements are grouped according to the section of this standard that defines or governs each activity. A description is given for each activity, and an activity sequence is illustrated in Figure 2.

Section 5 of this standard and NACE SP0102 provide the details of the process required to select an appropriate ILI system. The process of successfully performing an ILI begins with the operator defining inspection goals, objectives, and the pipeline system characteristics to service providers. Based on this information, the service provider and operator determine the relevant ILI systems to meet the project requirements.

Section 6 describes the processes that service providers shall use to define and determine performance specifications of their inspection systems. These performance specifications and essential variables define the ILI system capabilities.

Section 7 describes the requirements for preparing tools prior to physically performing inspections. It also describes the activities that shall be performed by the operator and/or the service provider during the inspection, and it covers verification that the inspection was run according to proper procedures.

Section 8 describes validation of the ILI system and the processes that shall be used for validating whether the tool meets the performance specifications. It also describes what shall be done if the performance specifications are not met.

“Verify” and “verification” refer to steps taken to ensure the ILI was conducted according to plan, procedures, and processes and that the inspection conditions are consistent with those used to establish the ILI service provider’s performance specification(s). The terms “validate” and “validation” refer to an evaluation of the accuracy of the reported anomaly types and characteristics (depth, length, width, etc.). A set of inspection results is validated if the accuracies are consistent with the performance specification.

- **Verify:** Ensure compliance with appropriate plans, procedures, and processes and that inspection conditions are consistent with those used to establish the performance specification(s) for the inspection system being used. A verified inspection should meet the performance specification(s).
- **Validate:** Ensure that the reported ILI results are consistent with the performance specification(s). A validated inspection is one that the pipeline operator considers consistent with the performance specification(s) and suitable for use in managing the integrity of a pipeline.

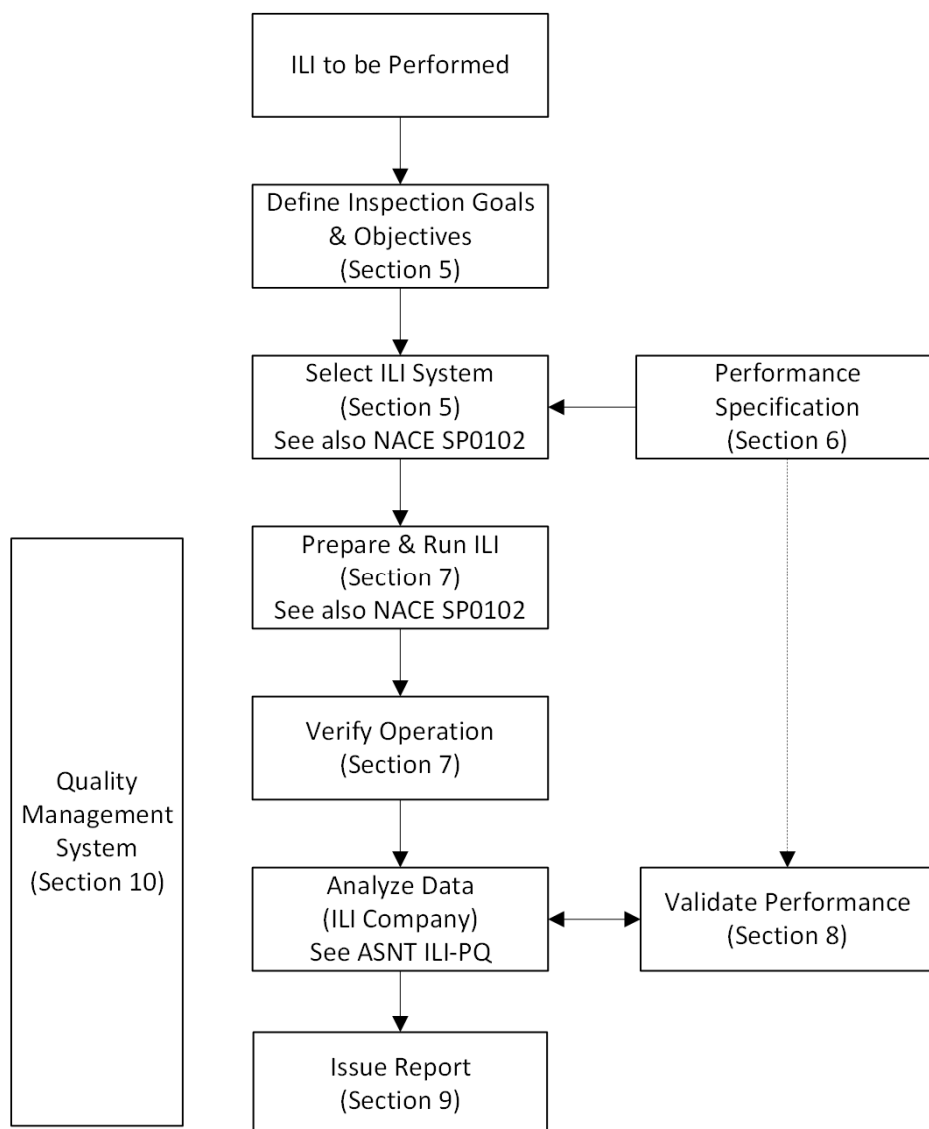


Figure 2—ILI Process Flow Diagram

Section 9 provides reporting requirements for the results of the inspections performed.

Section 10 establishes the quality system standards that are required of organizations that perform the services of ILIs in part or in full.

This standard provides the information and processes to enable operators and service providers to perform ILIs with greater consistency and accuracy.

4.2 Personnel Qualification

ASNT ILI-PQ is incorporated by reference as a requirement in this standard. The personnel operating the ILI systems and the personnel taking, reducing, analyzing, and reporting the resultant data shall be qualified in accordance with ASNT ILI-PQ.

NDE personnel used to generate data as part of the verification and validation process should be trained, certified, and competent in the appropriate testing method.

4.3 Operator and Service Provider Responsibilities

The accountable parties, as they would typically be designated, for the various tasks associated with an ILI are summarized in Table 1. Note that the accountable party may elect to designate the responsibilities to a third party. Nothing should preclude service providers and operators from agreeing that one party is responsible for activities or requirements that are typically performed by the other.

While the verification and validation step is designated by the operator, the operator should work in close cooperation with the service provider by providing field-validation results in the interest of continually improving the inspection technologies performance specification, sizing algorithms, or other variables.

Table 1—Suggested Operator and Service Provider Accountabilities

Tool selection	Operator
Pipeline configuration	Operator
Tool optimization	Service provider
Tool readiness	Service provider
Review of logistic plan for safety	Operator and service provider
Tool launch and receipt	Operator
Tool cleaning	Per agreement
Data quality assessment (DQA)	Service provider
DQA acceptance	Operator
Verification and validation	Operator

5 ILI System Selection

5.1 General

This section covers the selection of an ILI system. When selecting an ILI system, both the ILI system capabilities and the pipeline operational and physical characteristics shall be considered.

NACE SP0102-2017 may provide additional guidance.

Characteristics of available ILI technologies and tools are discussed in the NACE Publication 35100; however, this document does not address the full spectrum of currently available technologies.

5.2 Inspection Goals and Objectives

The goals and objectives of the ILI shall be defined by the operator in alignment with the integrity management program for which the API 1160 and ASME B31.8S may be used as a guidance. Operators shall define the adequate, implementable, and effective single, multiple, or combined systems required to achieve the inspection goals.

The following are some examples of inspection goals for pipelines:

- gather adequate and accurate inspection information to assess the integrity of the pipeline;
- monitor pipeline condition for new and previously identified integrity threats (e.g. inspection comparison, performance);
- increase efficiency and effectiveness of integrity programs (e.g. inspection methods, technologies).

The following are some examples of inspection objectives to achieve the above-mentioned goals:

- optimize the ILI implementation and its operational needs (e.g. flow speed vs deliveries, pipe cleanliness and data quality, first run success);
- obtain an acceptable inspection coverage and data quality for an integrity-targeted threat;
- detect integrity-targeted threat(s) with the selected inspection system(s);
- identify, characterize, or classify the integrity-targeted threat(s) with the selected inspection system(s);
- adequately size the integrity-targeted threat(s) with the selected inspection system(s);
- achieve adequate ILI performance (e.g. detection, sizing) for the validation process;
- obtain comparable inspection results for historical and trending integrity analysis;
- verify the quality management system implementation to ensure that ILI services meet the inspection's goals and expectations (see Section 10 for further details).

5.3 Physical and Operational Characteristics and Constraints

Consideration of physical and operational characteristics and constraints are covered in detail in NACE SP0102.

The operator shall provide information on physical characteristics and constraints of the pipeline to the service provider, which is typically done through a pipeline questionnaire. Characteristics of the pipeline that shall be provided for assessing the compatibility of the ILI system with the inspection goals and objectives are described in NACE SP0102.

For two-way flow, such as in storage operations, flow direction during inspection should be clearly defined.

The service provider shall define the constraints (minimum or maximum) under which the ILI tool will operate, such as the following:

- a) product temperature;
- b) internal line pressure;
- c) cleanliness of the pipeline;
- d) product characteristics that would limit or preclude a successful inspection;
- e) bend or elbow radii and spacing;
- f) flow velocities;
- g) line operation during anticipated inspection (e.g. intermediary injection points, flow stoppages, etc.);
- h) wall thickness;
- i) tool weight and overall length;
- j) special launching and receiving facilities constraints;
- k) check valve positions;
- l) bore requirements and drive cups compression;
- m) anticipated run length and any limitations on battery life, data storage capacity, and/or mechanical wear.

For additional details on the effect of product type on ILI, see 11.3.2 of the First Edition of API 1176. Operators may need to take samples of product when ultrasonic ILI technologies are used.

Due diligence should be used to ensure that the same product is used during the inspection. Having the wrong sample used to set up the tool can affect attenuation and the speed the sound travels can be incorrect.

The allowable operating conditions for the selected inspection tool(s) should be considered.

5.4 Selection of an ILI System

Selection of an ILI system is based on the operator's goals and objectives. The following factors should be evaluated on case-by-case basis.

- a) ILI technology selection (e.g. list of the identified and/or susceptible integrity threats vs the available state-of-the-art ILI technologies). References: API 1160 Table 3; API 1160 Annex B; API 1176, First Edition Table 1; NACE Publication 35100.
 - The operator should understand ILI performance against other integrity assessment techniques for the target threat considering operating conditions (e.g. medium and flow rate). The operator and service provider should share integrity related data to ensure that the inspection being performed will be effective for the target threat.
- b) ILI individual and combined tool selection. References: API 1160 B.5, B.6, B.7; API 1183 Annex E; NACE SP0102; API 1176 subsection 11.1 and Annex J.
 - Line segment specifics (e.g. diameter, wall thickness, and product type).
 - Expected performance of the ILI system regarding detection, classification, characterization, location, and coverage capabilities for the anomalies of interest and pipeline to be inspected.
- c) Pipeline readiness (e.g. operational constraints, fluid velocity, and availability).
- d) ILI tool safety requirements.
- e) Pipeline-ILI tool interaction (e.g. constraints of the joint pipeline-ILI tool application).
 - The operator may consider a review of the service provider's quality management procedures regarding tool assembly, component sourcing, and traceability in considerations of unusual loading regimes.
 - Tool recovery.
 - Unusual loading events or procedures.
 - Scenarios where a tool fails.
- f) ILI tool performance.
 - Primary performance (e.g. operational reliability of the ILI tool such as success track record, operational success, service provider).
 - Secondary performance (e.g. performance on other types of anomalies other than those of primary interest).
 - Track record demonstrating ability to sufficiently detect, size, and characterize the targeted threats.
- g) Expected results (e.g. field quality assurance, ILI reporting requirements).

The operator shall select the one or more appropriate ILI systems that meet the goals and objectives established in 5.2 (e.g. corrosion in dents, cracking with associated corrosion and/or dents, etc.). Operators should consider line segment specifics (e.g. diameter, wall thickness, and product type) to guide the selection of a technology.

The combination of ILI technologies and/or ILI tool specifications should be decided based on the expected threats results, to better understand the pipeline integrity condition, and to improve characterization of features.

The inspection objectives should be considered when selecting ILI systems for subsequent inspections. For example, when anomaly growth determination is the primary objective, running the same service provider and system repeatedly may provide the opportunity for better growth estimates. Alternatively, use of complementary systems from the same or different service providers may provide improved POD or identification.

The qualification of an ILI inspection for facility piping should consider the configuration of facility pipes that may include multiple bends, dual diameters, and other challenging design attributes.

5.5 Performance Specification

The service provider shall state whether the chosen ILI system can meet the written performance specification in that pipeline and under the existing operating conditions, including the specific tool configuration for the proposed run. Filtering or data retention thresholds should be reviewed and established in consideration of the anticipated anomaly population, when applicable.

6 Qualification of Performance Specifications

6.1 General

This section covers requirements for the qualification of performance specifications for an ILI system. The requirements of this section shall be met prior to an inspection run based on the anticipated inspection conditions. This section will outline the requirements for the parameters within a tool specification and how they should be demonstrated through testing or through a mutually approved approach.

The requirements in this section are written so that all concerned have a clear understanding of the ILI system's capabilities as defined in a performance specification for an ILI run. Within this section, the party that is typically responsible for meeting a requirement may be identified. Nothing in this section should preclude service providers and operators from agreeing that one party is responsible for activities or requirements that are typically performed by the other.

6.2 Performance Specifications

6.2.1 General

Performance specifications should define, using statistically valid methods, the ability of the ILI system to detect, locate, identify, and size pipeline anomalies, components, and features. An ILI system may be capable of addressing more than one type of anomaly or characteristic during an inspection run. If so, the performance specification shall address each type of anomaly or characteristic.

Detection is simply indicating that the feature is seen by the ILI system and apparent in the processed data. Whether a feature appears on the feature report listing is dependent on correct identification and sizing as applied to the reporting threshold.

It may not be possible to fully support all items in a performance specification by statistically valid methods. For example, detection and sizing near welds or other features is influenced by geometric and other weld characteristics, and it is not possible to statistically evaluate all permutations. In this case, the ILI service provider shall identify which parts of the performance specification are based on statistically valid methods and which are not, unless otherwise agreed to by the operator.

The performance specification shall define the capabilities of the ILI system to detect, locate, identify, size anomalies, and characterize in terms of the following parameters:

- a) the type of anomaly or characteristic covered by the performance specification;
- b) detection thresholds and PODs;
- c) probabilities of identification (POIs);
- d) sizing or characterization accuracies;
- e) linear (distance) and orientation measurement accuracies;
- f) limitations.

This standard recognizes that the capabilities listed above are interrelated. To provide uniformity and minimum requirements, this standard requires individual value or values for each parameter be given and requires that all significant interactions be defined.

Sizing or characterization accuracies will include:

- a tolerance representing a measure of the magnitude or range of the potential error;
- a certainty representing the likelihood that the sizing error falls within the range prescribed by the stated tolerance; the stated certainty level can be interpreted as the proportion of reported anomalies having an error that falls within the stated tolerance; given this interpretation, the stated certainty is effectively a proportion estimate that can be assessed using field measurements in combination with statistical methods that yield a measure of the confidence level that can be associated with the proportion estimate. (See Section 8.)

The performance specification shall state how the system will measure distance and how reference points will be utilized/required.

The performance specification shall state the geometrical limitations of the system in terms of passage capabilities through straight pipe, bends, and fittings.

6.2.2 Applicable Anomalies, Components, Features, and Characteristics

The performance specification shall clearly state the type or types of anomalies, components, and characteristics that are to be detected, identified, and sized by the ILI system in the line to be inspected.

Multiple feature types can be spatially coincident such that they interact to influence detection capability, accuracy, or severity of the anomaly as opposed to being independently assessed. Particular attention shall be given to how this coincidence is reported such that it is evident to the operator (i.e. it should be explicit). Types of anomalies may include, but are not limited to, the following.

a) Metal loss.

1) Corrosion (external and internal).

Additional characterization is typically based on the length, width, and depth criteria (typically regarding the wall thickness) that relate to detection and sizing capabilities. Figure 3 is a graphical representation of the dimensional classes typically associated with metal loss anomalies. 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 pipe wall thickness in the following manner:

If $t < 10$ mm, then $A = 10$ mm.

If $t \geq 10$ mm, then $A = t$.

2) Gouges/mechanical damage.

3) Mill anomaly (typically qualified with “possible”).

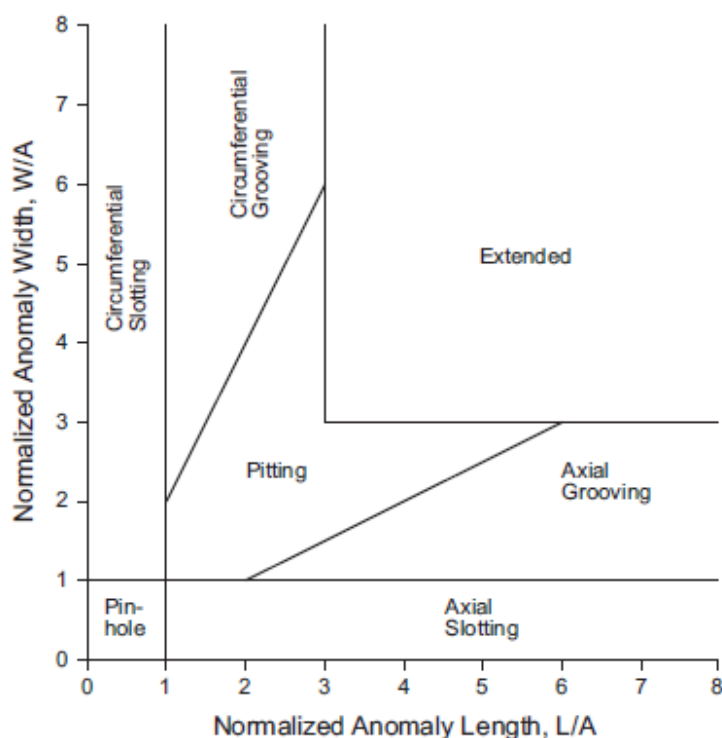


Figure 3—Dimensional Classes for Metal Loss Indications

b) Cracking anomalies:

- 1) isolated crack (e.g. crack-like);
- 2) crack colony (e.g. crack-field);
- 3) notch (e.g. notch-like);
- 4) seam weld cracks (this may otherwise be reported as an isolated crack at, or of, a seam);
- 5) girth weld cracks (this may otherwise be reported as an isolated crack at, or of, a girth weld).

c) Deformation:

- 1) dents;
- 2) ovality;
- 3) wrinkles or ripples;
- 4) buckling;
- 5) bulging or expansion.

d) Metallurgical:

- 1) cold work;
- 2) hard spots;
- 3) manufacturing anomalies (such as laminations, slugs, scabs, and slivers).

Components or other features may include, but are not limited to:

- a) valves, tees, fittings, and casings;
- b) other appurtenances, taps, metallic sleeves;
- c) girth welds, seam welds, or other end connections (couplings, bell/spigot connection, chill rings).

Characteristics may include, but are not limited to:

- a) geographic position of the centerline (or top) of the pipe;
- b) wall thickness and diameter changes;
- c) strain;
- d) pipe characteristics, such as manufacturing process (e.g. seamless, double submerged arc welding);
- e) locations of components or anomalies.

The list provided here is not designed to be exhaustive given that individual operators and service providers may extend and adapt this strategy to leverage the technology strengths, mitigate its weakness, and align with industry and operators' risk beliefs. The Pipeline Operators Forum's *Specifications and Requirements for Intelligent Pig Inspection of Pipelines* is a source of additional documentation regarding industry efforts to standardize and clarify these. Material from the Pipeline Operators Forum document has been presented in Annex A as an example performance specification template.

6.2.3 Detection Thresholds and PODs

The performance specification shall clearly state one or more detection thresholds and PODs that are statistically derived for each type of anomaly or characteristic covered by the specification.

The detection threshold(s) as a function of anomaly type should include the following, where applicable.

- a) Metal loss.
 - 1) Corrosion (external and internal): minimum depth, length, width, and orientation.
 - 2) Gouges: minimum depth, length, width, and orientation.
- b) Cracking anomalies (pipe body or weld). Minimum depth, length, width (opening), axial orientation (skew), radial orientation (tilt), and proximity to other cracks, anomalies, or pipeline attributes (such as seam or girth welds).
- c) Deformation.
 - 1) Dents: minimum depth, or reduction in cross section, or reduction in diameter and orientation.
 - 2) Pipe ovality: minimum ovality.
 - 3) Wrinkles or “ripples”: minimum height and spacing and orientation.
 - 4) Buckles: minimum depth or reduction in cross section or diameter and orientation.
 - 5) Expansion: internal diameter size.
 - 6) Blisters or midwall delaminations: reduction in cross section, or reduction in diameter and orientation.
- d) Metallurgical.
 - 1) Cold work: presence of and severity.
 - 2) Hard spots: minimum diameter of hard spot and difference in hardness between the hard spot and the base material.
 - 3) Manufacturing anomalies (such as laminations, slugs, scabs, and slivers): minimum dimensions and position.
- e) External coating faults, including disbonded coatings: minimum dimensions.
- f) External coating transitions.
- g) Girth welds, seam welds.
- h) Other anomalies, conditions, or pipeline components as required, dependent on industry standards or practices.
- i) Spatially coincident features (e.g. crack in corrosion).

For example, the detection threshold(s) and POD(s) may be stated in one of the following manners.

- a) Minimum dimension or characteristic that can be detected at a given POD. For example, a depth detection threshold and POD for metal loss could be stated as in Table 2, with the possible inclusion of the applicable reference anomaly for strictly informative purposes.

Table 2—Characterizing Metal Loss PODs—Example Depth Detection Thresholds

Reference Anomaly length by width	Example Detection Thresholds	POD	Qualifiers and Limitations
5t by 5t	10 % t	90 %	Extended metal loss; length and width > 3t
2t by 2t	15 % t	90 %	Pitting t < length and width < 3t
5t by 1t	35 % t	90 %	Axial slotting; width < t length > 3t
NOTE t = pipe wall thickness.			

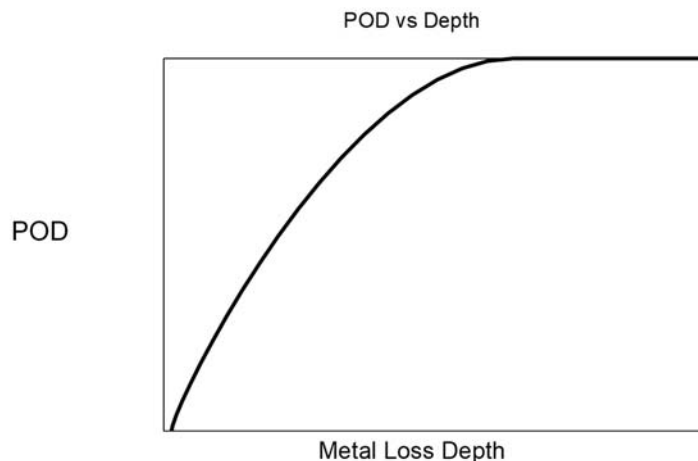
- b) Table 3 provides a similar example of characterizing the POD for a cracking ILI system. However, the qualifiers and limitations have been extended to account for proximity to welds.

Table 3—Characterizing Cracking PODs—Example Depth Detection Thresholds

Example Detection Threshold	POD	Type	Qualifiers and Limitations
10 % t	90 %	Isolated crack	In body of pipe
15 % t	80 %		Adjacent long seam
35 % t	70 %		Adjacent girth weld
10 % t	90 %	Crack colony	In body of pipe
15 % t	80 %		Adjacent long seam
35 % t	70 %		Adjacent girth weld
NOTE t = pipe wall thickness for a given length.			

- c) POD can also be described as a function of one or more characteristics of the anomaly as depicted in Figure 4.

In all cases, both detection threshold(s) and POD(s) shall be given. The detection threshold(s) and POD(s) should be statistically valid for the distribution of anomaly dimensions or characteristics reasonably expected for the inspection to be conducted.

**Figure 4—POD Function vs Metal Loss Depth**

When the detection threshold(s) and POD(s) significantly vary with anomaly dimensions or characteristics, individual detection thresholds and PODs shall be given for the range of anomaly dimensions or characteristics for which they are valid.

6.2.4 Probability of Identification

The performance specification shall clearly state a statistically derived and valid POI or a range of POIs for each type of anomaly, component, and characteristic covered by the specification. POI refers to the probability that an ILI system will correctly identify the type of anomaly conditional on it first being detected by the system. Table 4 provides an example of POI specifications in consideration of weld proximity.

Table 4—Example of Characterizing Cracking POIs

Type	Qualifiers and Limitations	Crack Depth	POI
Isolated crack	In body of pipe	1 mm	90 %
	Adjacent long seam	1.5 mm	80 %
	Adjacent girth weld	3 mm	70 %
Crack colony	In body of pipe	1.2 mm	90 %
	Adjacent long seam	1.8 mm	80 %
	Adjacent girth weld	2.75 mm	70 %
NOTE POI can be a function of crack depth, length, and other factors.			

POIs shall be established specifically for each classification type determined by the tool as their evaluation may depend on that classification. The service provider shall also clearly define the classification for any inspection indications detected but not reported as an artifact of their classification. The population statistics of these nonreported indications, in terms of per joint or in histograms, is to be provided to the operator upon request. These features may be indicative of potential false-negative calls, and an elevated concentration of them may be targeted for further analysis or correlation excavations by the operator. Specific consideration may be given to crack calls that are downgraded to an unreportable feature.

Additional information regarding reporting and classification can be found in Annex G.

6.2.5 Sizing Accuracy

The performance specification shall clearly state the sizing accuracies for each type and range of anomalies covered by the specification. A sizing accuracy refers to how closely the reported dimensions agree with the true dimensions.

Sizing or characterization accuracies shall include a tolerance (e.g. ± 10 wt % or ± 0.04 in. on depth sizing) and a certainty (e.g. 80 % of the time). Depth reporting may include a profile along the length of the feature, if available.

The performance specification shall clearly state the sizing capabilities for characteristics that are not covered in 6.2.2 and 6.2.3 but are included in the specification. Annex G provides additional guidance for accuracies related to burst pressure calculations.

The sizing accuracies should be statistically valid for the distribution of anomaly dimensions reasonably expected for the inspection to be conducted. When the sizing accuracies significantly vary with anomaly dimensions or characteristics, individual sizing accuracies shall be given for the range of anomaly dimensions for which they are valid.

6.2.6 Relative Positioning and Other Characterization Capabilities

The performance specification shall state a location accuracy from a fixed location and an orientation accuracy. When available, the performance specification should state the system's ability to compare repeat runs with the same tool type. This can be stated as an accuracy specification regarding the run-to-run comparison.

6.2.7 Limitations

Physical and operational factors or conditions that limit the detection thresholds, PODs, POIs, and sizing accuracies shall be identified in the performance specification. Examples of physical and operational factors that can limit detection thresholds, PODs, POIs, and sizing accuracies include:

- a) anomaly skew and tilt orientation;
- b) other coincident or interacting anomalies;
- c) anomalous seam geometry;
- d) anomaly shape;
- e) maximum and minimum pipe wall thickness (e.g. within a bend or in a "casing");
- f) ILI system speed outside of the specified range;
- g) pipeline cleanliness;
- h) pipe metallurgy;
- i) pipe curvature, field bend, or elbow;
- j) pipe wall coverage;
- k) acceptable sensor loss and associated data degradation.

Additional detail about POD can be leveraged by exception in response to specific circumstances. This could include to what extent the tool fidelity is diminished at elevated speed and proximity to welds that create sensor liftoff.

The change in detection threshold, POD, POI, and sizing accuracy that results from operation outside the range of acceptable conditions should be provided in the performance specification. Alternatively, no detection threshold, POD, POI, or sizing accuracy should be implied outside the range of acceptable conditions. Results for an inspection (or portion of an inspection) that are outside the range of acceptable conditions should be considered advisory.

6.2.8 Geometric Passage Capabilities

To assess the risk of the ILI system becoming lodged in the pipeline to be inspected, the inspection system's passage limitations shall be stated in terms of pipe geometry, taking into consideration the diameter of the inspection system's hardware components required to negotiate the pipeline without incurring damage. Such geometric limitations shall be measured or calculated for straight pipe runs, bends, and other fittings through which the system may pass during the inspection. Calculations shall consider the minimum clear diameter required by the inspection system for passage without damage and the most limiting dimensional tolerances allowed by industry standards in the manufacture of pipe, bends, and fittings. Considerations of pipe geometry tolerances may include diameter, wall thickness, ovality, bend radius, and branch/offtake diameter.

The performance specification shall state the ILI system's geometric limitations for straight pipe, bends, and fittings.

The specification shall state these limitations in terms of allowable pipe physical parameters, such as minimum inside diameter, maximum wall thickness, minimum bend radius, maximum branch/offtake diameter, and minimum required straight pipe length between bends. The performance specification shall also contain a statement, when applicable, that industry standards manufacturing tolerances were utilized in specifying these limitations.

If other tolerancing mechanisms are used, these shall be specified in the performance specification.

A gauging pig run or line proving tool may be conducted before an ILI tool run is conducted in that segment. Previous successful ILI tool passages can potentially be leveraged in lieu of running a gauge tool if mutually agreed upon between operator and service provider. Additional constraints or limitations that shall be stated are:

- a) run length;
- b) data storage capacity;
- c) launching and receiving trap requirements;
- d) required check valve positions or tool limitations with respect to valves.

6.2.9 Other Capabilities

Nothing in this standard precludes a service provider from including additional capabilities in a performance specification.

6.3 Qualification Requirements

6.3.1 General

Each performance specification shall be based on sound engineering practices, should be statistically valid, and shall include a definition of essential variables (see 6.3.2) for the ILI system.

The methodology used to qualify the performance specification shall be based on at least one of the following methods:

- a) verified historical data;
- b) full-scale tests from real or artificial anomalies; and/or
- c) small-scale tests, modeling, and/or analyses.

6.3.2 Essential Variables

The performance specification shall define and document the essential variables for the ILI system being qualified. Essential variables are characteristics or analysis steps that are essential for achieving desired results. Essential variables may include, but are not limited to:

- a) constraints on operational characteristics, such as product flow, wall thickness, pipe diameter, etc.;
- b) inspection tool design and physical characteristics, such as:
 - 1) inspection parameters (e.g. tool velocities, magnet strength, ultrasonic frequency, amplitude, and angle);
 - 2) sizing system components (e.g. sensor type, spacing, and location relative to the source of the inspection energy);
 - 3) analysis software or algorithm changes that could impact performance specifications.

Material changes to the essential variables of a system that can potentially impact ILI system performance shall require a new performance specification and qualification unless a documented rationalization to the contrary is developed and available for review by the operator. Service providers shall notify operator if any of the essential variables are out of specification for a run or materially different from previous runs so that the operator can make an informed decision as to how to leverage the data.

6.3.3 Data and Analyses Requirements

The data and analyses used to qualify a performance specification shall cover the full range of each essential variable defined for the specification. Data and analyses that are not within the range of essential variables defined for a performance specification shall not be used to qualify the specification.

Data and analyses used to qualify a performance specification shall be selected to generate a representative distribution of anomaly dimensions, components, and characteristics reasonably expected for the inspection to be conducted.

The analyses used to define the statistical quantities, such as PODs, POIs, and sizing accuracies, should be in accordance with standard statistical analysis methods and consistent with the amount of data used in the analyses.

Data and analyses used to qualify a performance specification shall be documented and maintained. For anomalies, the data shall include values of the essential variables during the inspection, inspection conditions (e.g. pressure, temperature, or velocity), reported anomaly characteristics, and verified anomaly characteristics.

When an ILI system is used for multiple inspections (as is the normal case), a database shall be established for the data and analyses used to qualify performance specifications. The database shall be used to improve accuracies when such values are included in future performance specifications. Changes in design or analysis procedures shall be accounted for and documented.

The qualification of a performance specification shall be considered valid for the range of essential variables defined for the specification. If data indicate that the ILI system does not meet the performance specification for any values or combinations of essential variables, the essential variables shall be redefined, or the performance specification shall be restated.

6.3.4 Validation Based on Historical Data

Validation measurements from previous runs of an ILI system may be used to qualify a performance specification. Validation measurements are dimensions and characteristics that have been physically measured after anomalies have been exposed.

Validation (NDE) measurements shall be performed by trained, qualified, and experienced technicians following well-established and recognized investigation protocols. The validation measuring methodologies shall be compatible with the type of defect to be evaluated. The validation measurements shall be detailed and well documented and should include three-dimensional profiling.

6.3.5 Validation Based on Full-scale Tests

Data from full-scale tests on real or artificial anomalies may be used for qualification provided the data are correlated or calibrated to field data. An example of a full-scale test used for qualification is a pull test. The methods by which the data are correlated or calibrated shall be documented.

6.3.6 Validation Based on Small-scale Tests, Modeling, and Analyses

Data from small-scale tests, modeling, and/or analyses may be used to demonstrate that the performance of a system component, such as a type of sensor, is consistent with data used for qualifying performance specifications.

Data from small-scale tests, modeling, and/or analyses shall be correlated or calibrated with historical field data or full-scale test data. The methods by which the data are correlated or calibrated shall be documented.

Data from small-scale tests, modeling, and/or analyses that are consistent with historical data and full-scale data may be used to qualify a change in system components and to extend the range of essential variables.

6.4 Documentation and Other Requirements

6.4.1 General

The methodology and data used to qualify a performance specification shall be fully documented and shall be available for review. This may include the analysis workflow (e.g. steps used in preprocessing, classification and characterization of signals, interaction rules) with its elements provided as version numbered references given the proprietary nature of the underlying details.

6.4.2 Detection Thresholds, PODs, and POIs

Detection thresholds, PODs, and POIs shall be based on historical or full-scale test data. If a significant amount of historical or full-scale test data is not available, the detection thresholds, PODs, and POIs shall be estimated using prior experience with other inspection systems, provided the estimates are clearly identified as such in the performance specification.

When using historical or full-scale data, detection thresholds shall represent the anomaly dimension(s) that shall be exceeded to achieve the POD. When the ILI system is operated within its essential variables and under the conditions planned for the inspection, it shall be able to detect anomalies that exceed the detection thresholds with the stated POD.

6.4.3 Sizing Accuracies

Evaluation of sizing accuracies shall be based on measurements from prior inspections or full-scale tests. If a sufficient quantity of historical or full-scale test data is not available, sizing accuracy may be estimated using statistically homogeneous small-scale test data, modeling results, analyses, and/or prior experience with other inspection systems, provided the estimates are clearly identified as such in the performance specification.

Sizing accuracies may be determined by comparing reported characteristics with validation measurements in accordance with applicable statistical methods as discussed in Section 8 and Annex C.

- Tolerances should be stated as the difference between a one-to-one relationship of the reported and actual dimensions. Tolerances may be stated as a value (e.g. ± 10 wt % or ± 0.04 in.) or a ratio (e.g. ± 10 % of the reported dimension).
- Certainties should be calculated based on the proportion of anomalies where the reported dimensions or characteristic are within tolerance.

Sources of differences between reported and measured characteristics should be identified, documented, and accounted for in the statistical analyses used to determine the tolerances, and certainties where practical. Sources of errors include those due to the ILI system, those due to characteristics measured by the analysis process, and measurement errors due to the NDE process. The tolerances and certainties required in this standard refer to errors due to the ILI system only. These errors include, but are not limited to, systematic errors (errors that result from known but unaccounted for causes, such as sensor liftoff), random errors (lack of repeatability and other errors with no identified cause), and anomaly-specific errors (errors in sizing particular to geometries or assemblies of anomalies).

6.4.4 Review and Revision Requirements

The qualification methodology shall be reviewed on a regular or periodic basis to ensure its continued validity. If the methodology is found to be no longer valid, any performance specifications that were validated by the methodology shall be revalidated by an acceptable methodology.

All reported significant errors in detection, identification, and sizing shall be investigated. Significant errors are those that are outside the performance specification or as defined by the operator (see Section 8).

The root cause(s) of all reported significant errors shall be determined and used to modify, as necessary, the analysis procedures and future performance specifications.

7 System Operational Verification

7.1 General

This section defines requirements for verifying that an ILI system is prepared and run in the manner defined as necessary to achieve the performance specifications as outlined in Section 6. Five (5) sets of requirements are given as follows:

- 1) ILI project;
- 2) pre-inspection;
- 3) inspection;
- 4) post-inspection;
- 5) ILI data analysis.

The requirements for the ILI project (see 7.2), pre-inspection (see 7.3), inspection (see 7.4), post-inspection (see 7.5), and the ILI data analysis (see 7.6) are detailed in the following subsections. Subsection 7.7 refers to the ILI system cumulative assessment of all above-mentioned requirements, and root cause analysis (RCA) (see 7.8) of failed runs provides some guidance on the data and information to be gathered and available methods.

CEPA's *Metal Loss Inline Inspection Tool Validation Guidance Document*, First Edition, 2016, provides some additional information on pre-run, in the pipe, and post-run process verification. A checklist that may support successful inspection planning and verification can be found in C.1.

7.2 Project Requirements

7.2.1 General

Project requirements ensure that the ILI system and operating conditions are consistent with those required to achieve the performance specifications described in Section 6. Project requirements should also ensure that all essential variables for the inspection are in their proper ranges.

When considering ILI for inspection of facility piping, the validation of ILI performance is paramount to measuring its effectiveness toward lowering risk likelihood; an accurate corrosion growth rate will build confidence in the program. This is especially important for pipe facilities where a risk-based inspection (RBI) methodology is being used.

For additional information, see NACE SP0102.

7.2.2 Data Collection and Analysis Requirements

It is important that all areas of critical data collection are identified if missing data or degraded data are encountered during the run.

Prior to the actual inspection, the operator and ILI service provider should agree on items such as:

- a) detection threshold for anomalies not included in the specification, or if requirements are different than the specification;
- b) reporting threshold for anomalies not included in the specification, or if requirements are different than the specification;
- c) sizing algorithms to use:
 - 1) filtering of reported anomalies;
 - 2) clustering rules;
 - 3) burst pressure calculation procedures, etc.;
- d) qualification needs for analysis personnel (i.e. Level 1, 2, or 3);
- e) proportion of signals to be manually verified in the data;
- f) requirements for comparison to previous inspection results.

7.2.3 Alignment of Technology and Pipeline Condition

Prior to the inspection, the pipeline geometry and planned pipeline operating conditions shall be reviewed to ensure that they are consistent with the information previously provided.

Historical performance of the inspection system should be reviewed by the operator to ensure that an appropriate tool has been selected considering the expected defect type(s) on the pipeline. The operator is encouraged to consult with available industry documents such as CEPA's *Metal Loss Inline Inspection Tool Validation Guidance Document*, First Edition, 2016.

The operator shall disclose to the service provider all changes in geometry or planned operating conditions before the ILI system is launched into the pipeline. The operator should also share any relevant data with the ILI service provider related to design, operation, or previous inspections that will lead to a successful assessment.

The service provider shall work closely with the operator to minimize the likelihood of damage to the pipeline or the inspection system.

The service provider shall confirm that the ILI system to be used for the inspection is consistent with that used to define the required performance specifications and that essential variables are within their qualified ranges. The service provider shall verify that a qualified crew, per ASNT ILI-PQ, is available to support running the ILI system.

7.2.4 Obtaining First Run Success

First run success, as agreed to by the ILI service provider and the operator, is a critical metric. First run success shall be tracked by the ILI service provider by tool technology. The criteria for first run success on facility pipe may be significantly different than mainline. The inspection plan for facility pipe may be prearranged as a partial inspection due to its configuration; it may only target a section of the pipe. This is especially applicable to new technology providers such as robotic applications with limited experience when compared to historical free-swimming tools used for mainline piping.