In-Line Inspections of Pipelines

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Section 1: General

1.1 The NACE standard for in-line inspection of pipelines is applicable to carbon steel pipeline systems used to transport natural gas, hazardous liquids including those containing anhydrous ammonia, carbon dioxide, water including brine, liquefied petroleum gases (LPG), and other services that are not detrimental to the function and stability of ILI tools.

1.2 This standard is primarily applicable to free-swimming ILI tools, but is not applicable for tethered or remotely controlled inspection devices.

1.3 This standard provides recommendations to the pipeline operator based on successful, industry-proven practices in ILI.

1.4 This standard is specific to the inspection of line pipe installed along a right-of-way, but the general process and approach may be applied to other pipeline facilities such as hydrocarbon distribution and gathering systems, water injection systems, station piping, and isolated crossings of railroads, highways, or waterways.

1.5 ANSI[(1)]/ASNT[(2)] ILI-PQ[2] establishes minimum requirements for the qualification and certification of ILI personnel whose jobs require specific knowledge of the technical principles of ILI technologies, operations, regulatory requirements, and industry standards as applicable to pipeline systems.

1.6 API[(3)] 1163[3] provides requirements for qualification of ILI systems used in onshore and offshore gas and hazardous liquid pipelines. This includes, but is not limited to, tethered or free-flowing systems for detecting metal loss, cracks, mechanical damage, pipeline geometries, and pipeline location or mapping. This standard is an umbrella document covering all aspects of ILI systems, including procedures, personnel, equipment, and associated software. It is performance-based, but it does not define how to meet qualification requirements.

Section 2: Definitions

Aboveground Marker (AGM): A portable or permanently installed device placed on the surface above a pipeline that both detects and records the passage of an in-line inspection tool or transmits a signal that is detected and recorded by the tool.

Anomaly: An unexamined deviation from the norm in pipe material, coatings, or welds. See also *Imperfection* and *Defect.*

Appurtenance: A component that is attached to the pipeline: e.g., valve, tee, casing, instrument connection, etc.

Batch, Batching: Separated volume of liquid within a liquids pipeline or of liquid within a gas pipeline. Sealing (batching) pigs are typically used for separation.

Bellhole: An excavation to permit a survey, inspection, maintenance, repair, or replacement of pipe sections.

Bend: A physical configuration that changes pipeline direction. A bend can be classified according to the centerline radius of the bend as a ratio to the nominal pipe diameter. A 1½ D bend would have a centerline radius of 1½ times the nominal pipe diameter. A 3 D bend would have a centerline radius of three times the nominal pipe diameter.

(1) American National Standards Institute (ANSI), 11 W. 42nd St., New York, NY 10036.
(2) American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Lane, Columbus, OH 43228-0518.
(3) American Petroleum Institute, (API) 1220 L Street NW, Washington, DC 20005-4070.

Buckle: A condition in which the pipeline has undergone sufficient plastic deformation to cause permanent wrinkling or deformation of the pipe wall or the pipe's cross-section.

Calibration Dig: An exploratory excavation to compare findings of an in-line inspection system to actual conditions with the purpose of improving data analysis. See also *Verification Dig*.

Caliper Pig: A configuration pig designed to record conditions such as buckles, dents, wrinkles, ovality, bend radius and angle, and occasionally, indications of significant internal corrosion by sensing the shape of the internal surface of the pipe (also referred to as geometry pig).

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

Check Valve: Valve that prevents reverse flow. Can cause damage to ILI tools if not fully opened.

Cleaning Pig: A utility pig that uses cups, discs, scrapers, or brushes to remove dirt, rust, mill scale, corrosion products, and other debris from the pipeline. Cleaning pigs are utilized to increase the operating efficiency of a pipeline or to facilitate inspection of the pipeline.

Combination Tool: An instrumented in-line inspection tool designed to perform both geometry (deformation) inspections as well as metal loss inspections with a single tool chassis.

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.

Corrosion: The deterioration of a material, usually a metal, that results from a chemical or electrochemical reaction with its environment.

Crack, Cracking: A fracture type of discontinuity characterized by a sharp tip and high ratio of length to width to opening displacement.

Data Analysis: The evaluation process through which indications are classified and characterized.

Defect: A physically examined anomaly with dimensions or characteristics that exceed acceptable limits. See also *Imperfection*.

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.

Deformation Tool: An instrumented in-line inspection tool designed to record geometric conditions such as buckles, dents, wrinkles, ovality, and bend radius and angle. See *Caliper Pig* and *Geometry Tool*.

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

Detect: To sense or obtain a measurable indication from a feature.

Electric Resistance Weld (ERW): A weld seam formed by resistance heating of the two edges of a pipe and then forcing them together.

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

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

Fatigue: The process of progressive localized permanent structural change occurring in a material subjected to fluctuating stresses less than the ultimate tensile strength of the material that may culminate in cracks or complete fracture after a sufficient number of fluctuations.

Feature: Any physical object detected by an in-line inspection system. Features may be anomalies, components, nearby metallic objects, welds, appurtenances, or some other item.

Gauging Pig: A utility pig mounted with a flexible metal plate or plates to gauge the internal diameter of the pipeline. Pipe bore restrictions less than the plate diameter or short radius bends will permanently deflect the plate material.

Geographical Information System (GIS): A computer system capable of assembling, storing, manipulating, and displaying geographically-referenced information.

Geometry Tool: An instrumented in-line inspection tool that records data about the geometric condition of the pipeline or pipe wall. Caliper tools and deformation tools are examples of geometry tools.

Girth Weld: A complete circumferential butt weld joining pipe or components.

Global Positioning System (GPS): The navigational system utilizing satellite technology to provide a user an exact position on the earth's surface.

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

Hydrostatic Test: A pressure test of a pipeline in which the pipeline is completely filled with water and pressurized to ensure it meets the design conditions and is free ofleaks.

Imperfection: An anomaly with characteristics that do not exceed acceptable limits. See also *Defect*.

Indication: A signal from an in-line inspection system. An indication may be further classified or characterized as an anomaly, imperfection, or component.

Induction Coil: A type of sensor that measures the time rate of change in magnetic flux density. Induction coils do not require power to operate, but have a minimum inspection speed requirement.

In-Line Inspection (ILI): An inspection of a pipeline from the interior of the pipe using an in-line inspection tool. Also called *intelligent* or *smart pigging*.

In-Line Inspection Tool (ILI Tool): The device or vehicle that uses a nondestructive testing (NDT) technique to inspect the pipeline from the inside. Also known as *intelligent* or *smart pig*.

Interaction Rules: A spacing criterion among anomalies that establishes when closely spaced anomalies should be treated as a single, larger anomaly.

Kicker Line: Piping and valving that connects the pressurizing pipeline to the launcher or receiver.

Lamination: An internal metal separation creating layers generally parallel to the surface.

Launcher: A device used to insert an in-line inspection tool into a pressurized pipeline. It may be referred to as pig trap or scraper trap.

Liquefied Petroleum Gas (LPG): Petroleum gases (butane, propane, etc.) liquefied by refrigeration or pressure to facilitate storage or transport.

Magnetic Flux Leakage (MFL): A type of in-line inspection technology in which a magnetic field is induced in the pipe wall between two poles of a magnet. Anomalies affect the distribution of the magnetic flux in the wall. The magnetic flux leakage pattern is used to detect and characterize anomalies.

Magnetic Particle Inspection (MPI): A nondestructive examination (NDE) technique for locating surface flaws in steel using fine magnetic particles and magnetic fields.

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

Metal Loss: Any pipe anomaly in which metal has been removed. Metal loss is usually the result of corrosion, but gouging, manufacturing defects, or mechanical damaging can also cause metal loss.

Nondestructive Examination (NDE): The evaluation of results from nondestructive testing methods or nondestructive testing techniques to detect, locate, measure, and evaluate anomalies.

Nondestructive Testing (NDT): A process that involves the inspection, testing, or evaluation of materials, components, and assemblies for materials' discontinuities, properties, and machine problems without further impairing or destroying the part's serviceability.

Nondestructive Testing Method (NDT Method): A particular method of NDT, such as radiography, ultrasonic, magnetic testing, liquid penetrant, visual, leak testing, eddy current, and acoustic emission.

Nondestructive Testing Technique (NDT Technique): A specific way of utilizing a particular NDT method that distinguishes it from other ways of applying the same NDT method. For example, magnetic testing is an NDT method, while magnetic flux leakage and magnetic particle inspection are NDT techniques. Similarly, ultrasonic is an NDT method, while contact shear-wave ultrasonic, and contact compression-wave ultrasonic are NDT techniques.

Operator: A person or organization that owns or operates pipeline facilities as an owner or as an agent for an owner.

Ovality: Out of roundness, i.e., egg shaped or broadly elliptical.

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. A pig may or may not be an in-line inspection tool.

Pig Signal: Usually a mechanical sensor on the pipe activated by the passage of a pig.

Pipeline: A continuous part of a pipe system used to transport a hazardous liquid or gas. Includes pipe, valves, and other appurtenances attached to the pipe.

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

Pipeline System: All portions of the physical facilities through which gas, oil, or product moves during transportation. This includes pipe, valves, and other appurtenances attached to the pipe, compressor units, pumping units, metering stations, regulator stations, delivery stations, tanks, holders, and other fabricated assemblies.

Pressure: Level of force per unit area exerted on the inside of a pipe or vessel.

Probability of Detection (POD): The probability of a feature being detected by an in-line inspection tool.

Pup Joint: A short piece of pipe, typically 3 m (10 ft) or less in length.

Receiver: A pipeline facility used for removing a pig from a pressurized pipeline. It may be referred to as trap, pig trap, or scraper trap.

RSTRENG:[4] A computer program designed to calculate the residual strength or failure pressure of corroded pipe.

RSTRENG 2: An enhanced version of RSTRENG as specified in the PRCI[(4)] project report PR-218-9205.[5]

Rupture: The instantaneous tearing or fracturing of pipe material causing large-scale product or water loss.

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

Sensors: Devices that receive a response to a stimulus, (e.g., an ultrasonic sensor detects ultrasound).

Shear Wave: Pertaining to pipe inspection, shear waves are generated in the pipe wall by transmitting ultrasonic pulses through a liquid medium. The same transducer is used for both sending and receiving ultrasound (so-called pulse echo technique). The angle of incidence is adjusted in such a way that a propagation angle of approximately 45° is obtained in the pipe wall. By using 45° shear waves, it is possible to detect radial-oriented, surface-breaking cracks at both sides of the pipe wall with high sensitivity, because the ultrasound pulse undergoes a strong angular reflection at the crack edge (so-called corner reflection).

Sizing Accuracy: The accuracy with which an anomaly dimension or characteristic is reported. Typically, accuracy is expressed by tolerance and a certainty. As an example, depth sizing accuracy for metal loss is commonly expressed as +/-10% of the wall thickness (the tolerance), 80% of the time (the certainty).

Slackline: The flow of product fails to completely fill the pipeline.

Smart Pig: See *In-Line Inspection Tool (ILI Tool).*

Strain: Increase in length of a material expressed on a unit length basis (e.g., millimeters per millimeter or inches per inch).

Survey: Measurements, inspections, or observations intended to discover and identify events or conditions that indicate a departure from normal operation of the pipeline.

Transducer: A device for converting energy from one form to another. For example, in ultrasonic testing, conversion of electrical pulses to acoustic waves, and vice versa.

Transmission Line: A pipeline, other than a gathering or distribution line, that transports gas from a gathering or storage facility to a distribution center or storage facility; operates at a hoop stress of 20% or more of the specified minimum yield strength of the pipe; or transports gas within a storage field.

Trap: A pipeline facility for launching or receiving tools and pigs. See *Launcher* and *Receiver*.

Ultrasonic Testing (UT): A type of inspection technology that uses ultrasound for inspecting pipe.

Verification Dig: An excavation made to verify the reported results of an in-line inspection. See *Calibration Dig*.

Wrinkle: A smooth and localized bulge visible on the outside wall of the pipe. The term wrinkle is sometimes restricted to bulges that are greater in height than one wall thickness. See *Buckle*.

Yield Strength: The stress at which a material exhibits a specified deviation from the proportionality of stress to strain. The deviation is expressed in terms of strain by either the offset method (usually at a strain of 0.2 percent) or the total-extension-under-load method (usually at a strain of 0.5 percent).

[(4)] Pipeline Research Council International (PRCI), 1401 Wilson Blvd., Suite 1101, Arlington, VA 22209.

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