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STATUS OF U.S. IN-LINE INSPECTION STANDARDS

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ABSTRACT

The U.S. gas and liquid pipeline industry and its regulators have been working to improve pipeline safety and integrity through a pipeline integrity management effort since 1999. The Office of Pipeline Safety of the U.S. Department of Transportation issued integrity management regulations for liquid pipelines in 2001 and issued similar regulations for gas pipelines at the end of 2003.

The Office of Pipeline Safety (OPS), also issued regulations for Operator Qualification in 1999 requiring personnel that perform certain tasks to be qualified to perform those tasks. The Integrity Management Programs require extensive inspections of pipelines and the primary method for these inspections is of course In-Line Inspection (ILI). These inspections are critical to the safety and integrity of pipelines and the requirements are reflected in ASME B31.8S Integrity Management for Gas Pipelines. However, neither the inspection systems nor the personnel operating the systems and analyzing and reducing the data have to be qualified under existing standards or regulations.

Industry and the Regulators agreed to embark on the development of consensus standards that would address the qualifications of both the ILI Systems and the ILI Personnel that run the systems and evaluate the inspection data.

This paper describes the 3 standards that have been developed to obtain "qualified" In-Line Inspection results:

API 1163: In-Line Inspection Systems Qualification

ASNT ILI-PQ-2003: In-Line Inspection Personnel Qualification

NACE RP0102-2002: Standard Recommended Practice, In-Line Inspection of Pipelines

The interrelationship of the 3 standards and how to utilize them will be discussed. (See figure 1). The latest changes to the standards and their acceptance by industry will also be described.

INTRODUCTION

The U.S. gas and hazardous liquid pipeline industry and its regulators have been working to further improve pipeline safety and integrity through pipeline integrity management programs. The Office of Pipeline Safety (OPS) in the U.S. Department of Transportation has issued liquid and gas pipeline integrity management regulations that require periodic assessments of pipelines in high consequence areas in order to determine the condition of these lines.

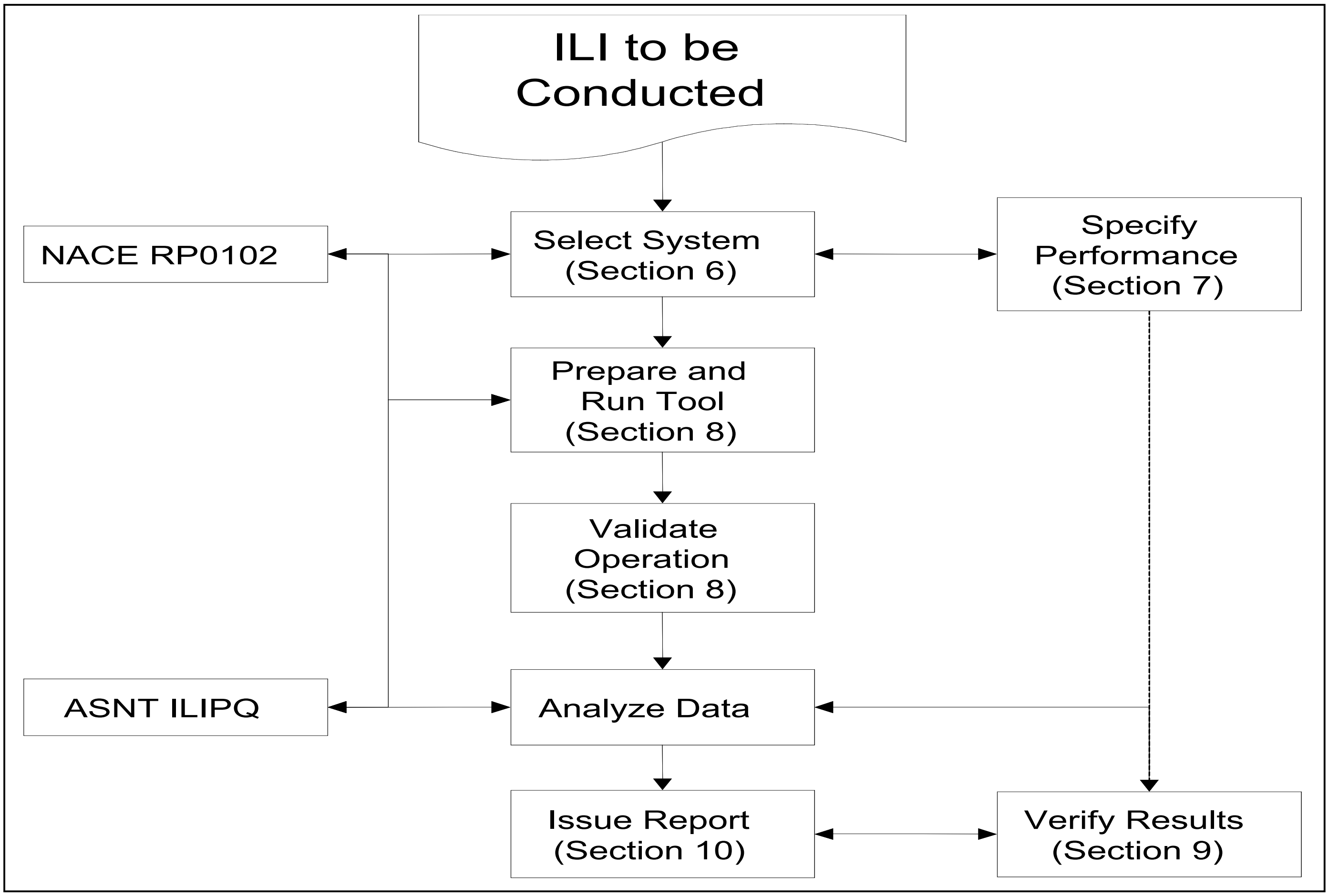
These assessments are critical to the safety and integrity of pipelines. The primary method chosen for these assessments is in-line inspection. Due to the nature of the existing OPS Operator Qualification regulation that was enacted in 1999, in-line inspection and the data reduction and analysis it requires are not considered as activities that require Operators to obtain qualified inspections under that existing regulation.

The pipeline industry and its regulators agreed that the criticality of these assessments warranted qualified inspection systems and personnel to conduct them.

In 2001, pipeline operators, in-line inspection (ILI) service providers and the regulators agreed to embark on the development of consensus standards that would address the qualifications of both the ILI Systems and the personnel that run the systems and analyze the inspection system data. With appropriate standards, it is anticipated that the quality, consistency and accuracy of ILI results will improve with time.

This paper describes the three ILI standards that were developed, why there are three standards, and how they are related.

FIGURE 1
IN-LINE INSPECTION PROCESS FLOW DIAGRAM – API 1163



* -Applicable sections in API 1163

APPLICABLE ILI STANDARDS AND THEIR RELATIONSHIP

Once the industry had decided to develop such standards, it was just a question of which standards developing organizations were appropriate and willing to undertake the development of the standards. NACE was already in the process of developing a standard recommended practice that was oriented toward the needs of the pipeline operator, covering such topics as tool selection, preparation for a successful ILI and data acquisition. API was willing to underwrite the development of the ILI systems standard, not including the qualification of the nondestructive testing/analysis personnel. ASNT was willing to undertake that function. And so the end result was three standards, one from NACE that was oriented towards the process of executing ILI inspections, ASNT for the qualification of the personnel and an API standard that concentrates on the ILI Systems qualification and incorporates the other two standards by reference to provide a complete "qualification" package. API 1163 defines an ILI system as –"An inspection tool and the associated hardware, software, procedures, and personnel required to perform and interpret the results of an in-line inspection."

Both ASNT ILI PQ-2004, In-Line Inspection Personnel Qualification and Certification Standard and NACE RP0102-2002, Standard Recommended Practice, In-Line Inspection of Pipelines, are fully incorporated into API 1163 by reference. (Fig.1) Simply put, in order to meet the requirements of API 1163, you must also meet the requirements of the other 2 standards.

At this point it is probably appropriate to remind everyone what a standard does and does not include. Standards are NOT regulatory or commercial documents. Standards describe practices and processes an industry should follow; what and sometimes how things should be done. It is only when a regulation requires the use of a standard that it becomes mandatory. Similarly, standards are not commercial documents. They cannot determine who should do what to whom. Antitrust concerns are a definite issue for standards developing organizations. API 1163 therefore does not identify who must perform the various functions required to conduct an in-line inspection. That is left to each individual pipeline operator and their service providers to determine.

Table 1*
Types of ILI Tools and Inspection Purposes (NACE RP 0102)

ILI PURPOSE	METAL-LOSS TOOLS			CRACK-DETECTION TOOLS		CALIPER TOOLS	MAPPING TOOLS
	Magnetic Flux Leakage (MFL)		Ultrasonic (compression wave)	Ultrasonic (shear wave)	Transverse MFL		
	Standard-resolution (SR) MFL	High-resolution (HR) MFL					
METAL LOSS (CORROSION) External corrosion Internal corrosion	detection,(A) sizing,(B) no ID/OD(C) discrimination	detection,(A) sizing(B)	detection,(A) sizing(B)	detection,(A) sizing(B)	detection,(A) sizing(B)	no detection	no detection
NARROW AXIAL EXTERNAL CORROSION	no detection(A)	no detection(A)	detection,(A) sizing(B)	detection,(A) sizing(B)	detection,(A) sizing(B)	no detection	no detection
CRACKS AND CRACK-LIKE DEFECTS (Axial) Stress corrosion cracking Fatigue cracks Longitudinal seam weld imperfections Incomplete fusion (lack of fusion) Toe cracks	no detection	no detection	no detection	detection,(A) sizing(B)	detection,(A)(D) sizing(B)	no detection	no detection
CIRCUMFERENTIAL CRACKING	no detection	detection,(D) sizing(D)	no detection	detection,(A) sizing(B) if modified(E)	no detection	no detection	no detection
DENTS SHARP DENTS WRINKLE BENDS BUCKLES	detection(F)	detection,(F) sizing not reliable	detection,(F) sizing not reliable	detection,(F) sizing not reliable	detection,(F) sizing not reliable	detection,(G) sizing	detection, sizing not reliable
	In case of detection, circumferential position is provided.						
GOUGES	Detection(A) and Sizing(B)						no detection
LAMINATION OR INCLUSION	limited detection	limited detection	detection, sizing(B)	detection, sizing(B)	limited detection	no detection	no detection
PREVIOUS REPAIRS	detection of steel sleeves and patches, others only with ferrous markers		detection only of steel sleeves and patches welded to pipe	detection only of steel sleeves and patches welded to pipe	detection only of steel sleeves and patches, others only with ferrous markers	no detection	no detection
MILL-RELATED ANOMALIES	limited detection	limited detection	detection	detection	limited detection	no detection	no detection
BENDS	no detection	no detection	no detection	no detection	no detection	detection, sizing(H)	detection, sizing
OVALITIES	no detection	no detection	no detection	no detection	no detection	detection, sizing(B)	detection, sizing(B)(I)
PIPELINE COORDINATES	no detection	no detection	no detection	no detection	no detection	no detection	detection, sizing

(A)Limited by the minimum detectable depth, length, and width of the defects.
(B) Defined by the specified sizing accuracy of the tool.
(C) Internal diameter (ID) and outside diameter (OD).
(D) Reduced probability of detection (POD) for tight cracks.
(E) Transducers to be rotated by 90°.
(F) Reduced reliability depending on the size and shape of the dent.
(G) Depending on the configuration of the tool, also circumferential position.
(H) If equipped for bend measurements.
(I) If the tool is equipped for ovality measurement.
Shaded area indicates ILI technologies that can be used only in liquid environments, i.e., liquids pipelines or in gas pipelines with a liquid couplan.

- - From NACE RP0102

NACE RP0102-STANDARD RECOMMENDED PRACTICE – IN-LINE INSPECTION OF PIPELINES

This standard recommended practice describes a process of related activities to plan, organize and execute an ILI project. Guidelines pertaining to ILI data management and data analysis are included.

RP0102 was a progression from the NACE state of the art report, "In-Line Nondestructive Testing of Pipelines", NACE publication 35100, published in 2000. This report was the first industry attempt to document the types and capabilities of various ILI tools available for inspecting pipelines.

The standard is applicable to carbon steel pipeline systems used to transport natural gas, hazardous liquids including anhydrous ammonia, carbon dioxide, and water, including brine and liquefied petroleum gases. The standard is primarily applicable to "free swimming" ILI tools but not tethered or remotely controlled inspection devices.

Table 1 of RP0102 (Table 1) provides a guide for picking the appropriate ILI tool for the specific threats to be evaluated from an integrity perspective.

The pipeline operators' chief responsibilities for obtaining a successful inspection as enumerated in this standard are:

- Provide a clean pipeline
- Identify varying geometries and obstacles to inspection devices
- Maintain the pipeline velocities within the range required for the inspection

RP0102 is undergoing its first revision since it was issued. It will be brought into alignment with API 1163, especially in the definitions section. It is incorporated by reference into API 1163.

ASNT ILI PQ -2004 IN-LINE INSPECTION PERSONNEL QUALIFICATION & CERTIFICATION

This standard establishes minimum requirements for the qualification and certification of in-line inspection personnel whose jobs require specific knowledge of the technical principals of ILI technologies, operations and other requirements of the pipeline industry.

As with other ASNT qualifications, there are three levels of qualifications, I, II & III in ascending order of technical and job experience/training. Two types of personnel require qualification, tool operators and data analysts. Tool operators are defined as any person performing tool operator covered tasks. Data analysts are defined as any person performing data analysis covered tasks. Data analysis is the process through which indications recorded in an ILI are evaluated to classify, characterize and size them.

A covered task is any job duty that this standard deems to be critical in the execution of an in-line inspection and therefore requires qualification.

Each level of qualification permits certain tasks to be performed by that qualified individual.

As an example, Table 2 provides a comparison of the tasks the different levels of data analysts are permitted to perform.

Table 2
ASNT Permissible Tasks – Data Analyst

ILI Data Analyst	Permitted Covered Tasks
Level I	Basic analysis as described in employers' written practice.
Level II	In field inspection data confirmation Integration & confirmation of supplementary data Data preparation & processing Feature detection & location Feature categorization & evaluation Feature sizing Application of anomaly interaction rules Standard & non-standard analysis Organize & report ILI tool results Provide supervision, training to trainees & level I ILI data analysts.
Level III	All of the above plus: Establish techniques and procedures Interpret codes and standards Review customers specification requirements Advanced data analysis Final report analysis review Provide supervision, training to ILI Data Analyst Level I, II & III

The standard provides recommended minimum education, training and experience requirements for the 3 levels of the two types of personnel for different ILI technologies.

Table 3 provides the example for Axial Magnetic Flux Technology.

ASNT ILI PQ is also fully incorporated into API 1163 as a requirement, thus qualifying both the personnel and ILI systems that are used to perform in-line inspections.

Table 3
Axial Magnetic Flux Technology

Table 2A – ILI Tool Operator

Level	Experience (Months)	Training (Hours)	Education (Formal)
Level I	6	80	*
Level II	18	160	*
Level III	30	320	**

Table 2B – ILI Data Analyst

Level	Experience (Months)	Training (Hours)	Education (Formal)
Level I	6	80	*
Level II	24	160	*
Level III	36	500	**

* - High School Graduate or Equivalent
** - Completion, with a passing grade, of at least 2 years of engineering or science study at a university, college or technical school.

API 1163 IN-LINE INSPECTION SYSTEMS QUALIFICATION STANDARD

This standard covers the qualification of in-line inspection systems for onshore and offshore gas and hazardous liquid pipelines. The standard 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, utilizing existing and developing technologies.

Figure 1 depicts the process that is used to qualify an ILI family of tools. The standard defines a family of tools as ones that have the same "essential variables", a common set of characteristics or analysis steps for a family (series) of in-line inspection tools that may be covered within one performance specification. A performance specification is a written set of statements that define the capabilities of an in-line inspection system to detect, classify, and characterize anomalies and other features.

As an example, an ILI service provider may have a set of high resolution MFL tools with a range of diameters. One performance specification qualification will cover this family of tools, as long as they all have the same essential variables.

There are 3 methods permitted for qualifying systems;

1. The use of historic data, previous runs with actual measurements of anomalies compared to ILI data.
2. Data from full scale tests on real or artificial anomalies that are calibrated to field data.
3. Data from small scale tests, modeling and or analyses may also be used, provided that they are correlated or calibrated to field test data.

The ILI systems must also be operationally checked prior to a run and immediately after a run, to ensure that the tool was properly assembled and that the run was an acceptable run. This is called "System Operational Validation" in the standard. Details of those requirements are included in the standard.

The results of the inspection must be analyzed to make sure that they have met the performance specification. This is called "System Results Verification" in the standard. If the operator digs up pipe and examines anomalies after an ILI inspection, perhaps as a requirement of an integrity program, he must report the results of those digs back to the service provider so that the service provider can evaluate the measured results against the ILI tool results. This permits the service provider to statistically determine whether he has indeed met the stated performance specification. Additionally, the service provider builds up a database of historical data that can be used to validate and improve the tools performance.

There are three permitted methods for verifying a tool run:

1. Comparison with prior data from the existing line
2. Comparison of other data from the same inspection system
3. Performing verification measurements after the run.

The standard has appendices that help define formats for performance specifications, verification measurements, reporting results and statistical analyses that can be used to evaluate whether the performance specification has been met. The standard provides some details to define Probability of Detection (POD) and Probability of Identification (POI) and other similar technical details.

Additionally, the standard has requirements for management of change and quality control.

To effectively get the most value out of an ILI inspection, an operator and ILI service provider must work closely together. Because a standard is not a commercial document, the standard does not describe who has to perform which functions. That is left up to the operator and the service provider to negotiate. Operators have different ways of managing their inspections and service providers have different scopes of supply and a standard cannot define these. When an operator and a service provider have agreed on a scope for an inspection, the operator can invoke the use of API 1163 and the 2 companion standards in the contract with the service provider. The contract should clearly define the scope for the service provider. The operator is then responsible for providing the remaining efforts required in the 3 standards in order to successfully complete an ILI inspection.

The results of the in-line inspections will be utilized for pipeline integrity assessments. While they are closely coupled, this standard's scope does not deal with integrity assessment issues such as interaction rules and when "discovery" occurs.

These are addressed in ASME B31.8, B31.8S, B31.4, B31G and API 1160 and the OPS regulations.

CONCLUSIONS

Three complementary standards have been written that in combination, provide the processes and information required to plan and execute a "qualified" in-line inspection, i.e., an inspection that has utilized qualified personnel and equipment and has been performed with a "standardized" process.

Industry anticipates that the use of these standards will improve the input to integrity assessment programs and thus ultimately, improve pipeline integrity.