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Petroleum and natural gas industry — Pipeline transportation systems — Pipeline integrity assessment specification

Industries du pétrole et du gaz naturel — Systèmes de transport par conduites — Spécification d'évaluation de l'intégrité des conduites

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, Subcommittee SC 2, *Pipeline transportation systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Petroleum and natural gas industry — Pipeline transportation systems — Pipeline integrity assessment specification

1 Scope

This document specifies requirements and gives recommendations on the integrity assessment of pipelines of various applications as part of pipeline systems.

This document is mainly applicable to onshore pipeline systems, connecting wells, production plants, process plants, refineries and storage facilities, including any section of a pipeline constructed within the boundaries of such facilities for connection purpose, according to ISO 19345-1. The principles can also be used for offshore pipelines where applicable and practical.

This document applies to rigid, steel pipelines. It is not applicable for flexible pipelines or those constructed from other materials, such as glass-reinforced plastics.

This document does not cover all conditions which might be related to pipeline integrity. A competent pipeline integrity engineer can evaluate whether additional requirements are necessary.

This document does not cover the assessment of pipeline defect(s) found during fabrication/construction or installation, which would need to be done in accordance with the applicable standards of design, construction, material procurement and welding process applicable at that time. However, this document can be applied to the ongoing monitoring and assessment of known flaws from the time of construction.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 19345-1:2019, *Petroleum and natural gas industry — Pipeline transportation systems — Pipeline integrity management specification — Part 1: Full-life cycle integrity management for onshore pipeline*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
alternating current attenuation survey
ACAS
method of measuring the current attenuation along the pipeline to assess general quality of the coating by applying the electromagnetic field propagation theory

3.1.2
comprehensive assessment
evaluation using two or more separate integrity data sets

3.1.3
corrosion
deterioration of a material, usually a metal that results from an electrochemical reaction with its environment

[SOURCE: ISO 19345-1:2019, 3.1.5]

3.1.4
crack
planar flaw, or linear discontinuity, with a sharp tip radius

[SOURCE: ISO 19345-1:2019, 3.1.6]

3.1.5
data transferability
use of data from similar pipelines (in terms of geometry, material, service, environment) to supplement or replace data that cannot be obtained, or are difficult to obtain, on the pipeline being evaluated

3.1.6
deformation
change in shape of the pipe or component, such as a bend, buckle, dent, ovality, ripple, wrinkle, or any other change that affects the roundness of the pipe or original cross-section or straightness of the pipe or component

[SOURCE: ISO 19345-1:2019, 3.1.9]

3.1.7
defect
imperfection of a type or magnitude exceeding acceptable criteria

[SOURCE: ISO 19345-1:2019, 3.1.10]

3.1.8
degradation modelling
models to evaluate degradation of materials

3.1.9
dent
depression which produces a disturbance in the curvature of the pipe wall, caused by contact with a foreign body resulting in plastic deformation of the pipe wall

[SOURCE: ISO 19345-1:2019, 3.1.11]

3.1.10
direct inspection
methodology used to detect and characterize pipeline defects and condition at a specific location

3.1.11
failure
event in which a component or system does not perform according to its operational requirements

[SOURCE: ISO 19345-1:2019, 3.1.14]

3.1.12
fitness for purpose
FFP
quantitative engineering evaluation that is performed to demonstrate the structural integrity of an in-service component that can contain an imperfection, defect or damage

[SOURCE: ISO 19345-1:2019, 3.1.15]

3.1.13
gouge
surface damage to a pipeline caused by contact with a foreign object that has scraped (gouged) material out of the pipe, resulting in a metal loss defect or imperfection

[SOURCE: ISO 19345-1:2019, 3.1.16]

3.1.14
in-line inspection
ILI
inspection of a pipe wall from the interior of the pipe using specialized tools

[SOURCE: ISO 19345-1:2019, 3.1.19]

3.1.15
integrity assessment
process that includes the inspection and testing of a pipeline in order to determine physical characteristics and assess its integrity condition by combination of an analysis of data, use of reliability assessment methodologies of the structure and an evaluation of the safety state of the pipeline

[SOURCE: ISO 19345-1:2019, 3.1.20]

3.1.16
magnetic flux leakage
MFL
type of in-line inspection technology in which a magnetic field is induced in the pipe wall between two poles of a magnet

Note 1 to entry: Anomalies affect the distribution of the magnetic flux in the pipe wall. The magnetic flux leakage pattern is used to detect and characterize anomalies.

[SOURCE: ISO 19345-1:2019, 3.1.24]

3.1.17
maximum allowable operating pressure
MAOP
maximum internal pressure at which a pipeline system, or parts thereof, is allowed to be operated

Note 1 to entry: The MAOP is established by the maximum pressure achieved during testing (see ISO 13623).

[SOURCE: ISO 19345-1:2019, 3.1.27]

3.1.18
metal loss
pipe wall anomaly in which metal has been removed

Note 1 to entry: Metal loss is usually the result of corrosion, but gouging, manufacturing defects, erosion, or mechanical damage can also result in metal loss.

[SOURCE: ISO 19345-1:2019, 3.1.28]

3.1.19
non-destructive testing
NDT
analysis techniques used to evaluate the properties of a material, component or system without causing damage

Note 1 to entry: “Non-destructive inspection” (NDI) and “non-destructive evaluation” (NDE) are also commonly used to describe this technology.

[SOURCE: ISO 19345-1:2019, 3.1.29]

3.1.20
pressure test
means of assessing the integrity of a new or existing pipeline that involves filling the pipeline with water, dry air or nitrogen, and pressurizing to a level reasonably in excess of the MAOP of the pipeline to demonstrate that the pipeline is fit for operating condition

[SOURCE: ISO 19345-1:2019, 3.1.34, modified — “dry air or nitrogen” “reasonably” added, “for a given time frame dependent on the identified integrity hazards” deleted and “service at the MAOP” replaced by "operating condition"; Note to entry deleted.]

3.1.21
sizing accuracy
accuracy with which an anomaly dimension or characteristic is reported

Note 1 to entry: Typically, accuracy is expressed by tolerance and certainty.

EXAMPLE Depth sizing accuracy for metal loss using NDT methods, such as an ILI tool, is commonly expressed as +/-10 % of the wall thickness (the tolerance) and 80 % of the time (the certainty).

[SOURCE: ISO 19345-1:2019, 3.1.40]

3.1.22
stress corrosion cracking
SCC
cracking of a material produced by the combined action of corrosion and sustained tensile stress

3.2 Abbreviated terms

AC/DC	alternating current/direct current
ACVG	alternating current voltage gradient
CIPS	close interval potential survey
DCVG	direct current voltage gradient
EMAT	electromagnetic acoustic transducer
FFP	fitness for purpose
IMP	integrity management program
IMU	inertial measurement unit
LSM	large standoff magnetometry
POD	probability of detection
POI	probability of identification

SCT	stress concentration tomography
TEM	transient electromagnetic method
TFI	transverse flux inspection
USCD	ultrasonic crack detection
USCCD	ultrasonic circumferential crack detection
UT	ultrasonic compression wave tool

4 General

4.1 Key principles

Pipeline operators shall assess the integrity condition and safety state of their operated pipelines by using a suite of inspection, monitoring and evaluation techniques/methodologies. Local laws and regulations can apply for the integrity assessment. New technologies should be encouraged for application, when they are proved to be effective, safe and to follow industry practices. The key principles for integrity assessment are listed below.

a) Threats and degradation modes shall be identified accurately for the integrity assessment.

b) Relevant data shall be collected, as it constitutes the fundamental basis for a sound integrity assessment. Data sets shall be used to determine the defect types and failure mechanisms of the pipeline and to provide a basis for the selection of the most appropriate assessment methods. The pipeline assessment method shall be selected in accordance with the damage mechanisms, type, dimensions, distribution, expected activity and progression rates of defects affecting the pipeline and the purpose of the assessment.

c) One or more assessment methods shall be selected based on data collected from ILI, direct inspection, pressure test or others. When ILI is applicable, it shall be selected as a priority.

d) Historical records of past failures and executed repairs shall be considered for assessment method selection.

e) The interval of pipeline integrity assessment shall be determined by previous assessment result. If leaks or ruptures occur in between integrity assessments, then, the interval shall be immediately re-evaluated based on the results of failure analysis (e.g. cause and contributing factors).

f) Knowledge and ability related to integrity assessment shall be possessed by the practitioners.

g) Relevant requirements of ISO 19345-1:2019 shall be applied, and other international practice standards should be considered as technical support.

4.2 Pipeline integrity assessment process

4.2.1 The pipeline integrity assessment process shall be continuously improved. Experience obtained from each assessment assists in determining the most appropriate method for subsequent assessments.

4.2.2 The pipeline integrity assessment process should follow the sequence shown in Figure 1, including:

a) data collection and analytics;

b) pipeline condition inspection and monitoring;

c) hazard identification;

d) FFP assessment;

e) assessment report.

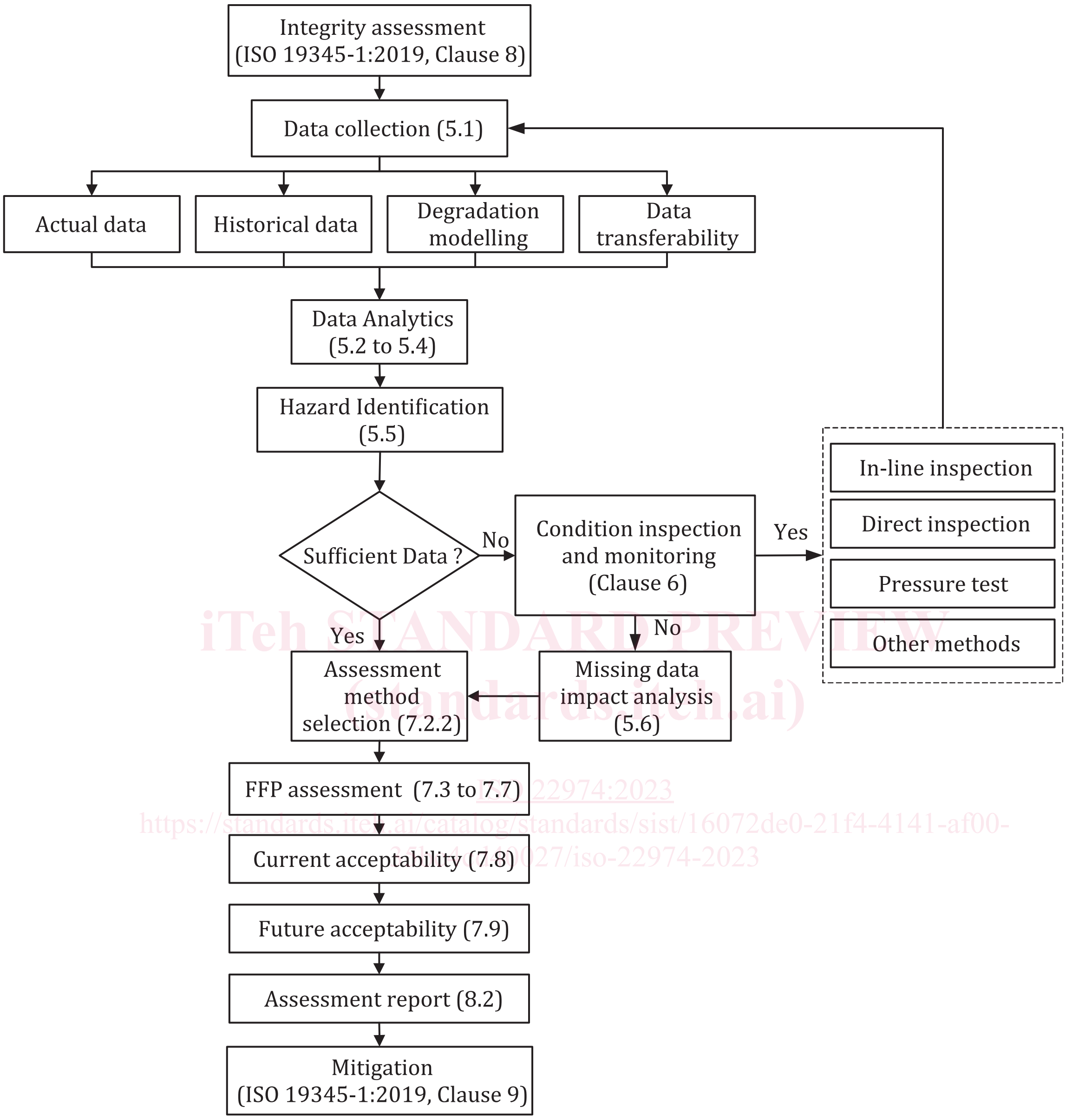

Figure 1 — Recommended pipeline integrity assessment process

4.2.3 The assessment of the remaining pipeline strength and remaining life affected by the presence and type of defects is the core of integrity assessment, and shall be carried out by considering factors related to service history and external environment.

4.2.4 Comprehensive assessment should be carried out given multiple data generated from different sources, such as various inspection methods or time periods.

5 Data collection and analytics

5.1 Data collection

5.1.1 The scope of data collection should be determined according to the pipeline properties, potential damage mechanism, assessment methodologies, etc. to evaluate threats, or potential threats, and damage mechanism(s) for the pipeline. Relevant data and information can be collected along the entire pipeline life cycle such as design, construction, operation and maintenance phases. When the pipeline data is deemed insufficient for the integrity assessment, other relevant data such as failure analysis and integrity assessment reports of pipelines with similar operating conditions should also be collected as reference. When data transferability is used to determine the FFP of a pipeline, the assessor should apply conservative factors or allowances to recognize the added uncertainty.

For example, the pipeline whose material properties cannot be obtained can refer to the test results of pipelines with similar construction years, same steel grade, same manufacturing processes, same pipe manufacturer, same quality control applied during construction and any other relevant information.

5.1.2 The data used for pipeline integrity assessment should include:

a) Pipeline attributes: steel grade, diameter, wall thickness, weld type, fluid type, coating type and cathodic protection, accessory infrastructures, burial conditions.

b) Mechanical properties, such as tensile properties, engineering stress/strain curve, fracture toughness.

c) Inspection reports and data, such as ILI, NDT, direct inspection and SCT.

d) Design and operating parameters, such as fluid composition, maximum allowable operating pressure, maximum/minimum operating temperature.

e) Construction data, such as welding records, pressure testing, welding procedure specifications, NDT results.

f) Historical data, such as in-service pressure testing, excavation verification, repair, failure(s) and maintenance data.

g) Load data, such as service load, environmental load, construction load or other additional load.

h) Degradation modelling, such as corrosion growth model, fatigue model, crack extension model, SCC model.

i) Environmental conditions, such as corrosiveness of the environment, crossing of railways, highways and rivers and as well as geotechnical and geographical information.

j) Transferable data from similar pipelines.

k) Other data, such as regional grades, critical consequence areas, risk assessment results.

5.2 Data quality

The quality of data available should be determined, including the allowance for varying data quality over historical events, and identify a confidence level that can be applied to the resulting assessment. It should be determined whether the data quality is sufficient to enable an FFP assessment to be completed to the required certainty according to the criticality of the system, which should conform to the dimensions outlined below, as applicable:

a) Accuracy: Data accuracy should be examined by analysis and verified between different data sources.

b) Completeness: It should be checked that all needed data is available.

c) Consistency: The data should be free of internal contradictions.

d) Precision: The data should be exact as required.

e) Granularity: The data should be kept and presented at the right level of detail to meet the requirements of FFP assessment.

f) Timeliness: The data should be as current as needed and should be retained no longer than required.

5.3 Data alignment

5.3.1 Data from different sources shall be aligned based on the data with higher accuracy.

5.3.2 The data alignment content shall be determined in accordance with the pipeline attributes and damage mechanism. For example, for external corrosion, the ILI data can be aligned with the pipeline attributes, coating, cathodic protection, stray current interference, soil corrosiveness, direct inspection and other relevant data. For internal corrosion, it can be compared with the data of pipeline elevation, including ILI data, data of pipeline evaluation by other methods, medium composition, flow, temperature, pigging products, etc.

5.3.3 For alignment of two or more ILI data sets, girth welds should be aligned prior to assessing the defects or features of interest. Inspection accuracy and defect growth should be subsequently analysed.

5.3.4 When data of ILI and other different inspection methods are available, other data should be aligned with the ILI data. If ILI has not been carried out, it should be carried out first. If the pipeline is unpiggable, other inspection method such as direct inspection at selected critical area should be adopted. The data should be then aligned to the ground mapping data.

5.4 Data analysis

5.4.1 A comprehensive analysis of the aligned data should be carried out to determine the cause of defect(s) and arresting mitigating measures.

5.4.2 A defect statistical assessment should be performed to determine the severity, distribution, and the relationship between different types of defects. The cause and initiation of the defect(s) should be determined.

5.4.3 The cause and rate of defect growth should be analysed using multiple sources of data when possible. If necessary, excavation can be used to verify the causes of actively growing defect(s).

5.5 Hazard identification

5.5.1 Hazards shall be analysed using integrated data from various sources.

5.5.2 Hazards should be delineated into time-related, time-independent and inherent factors categories as follows:

a) Time-related hazards, including external corrosion, internal corrosion, SCC/hydrogen-induced cracking, fatigue damage, etc.

b) Time-independent factors, including mechanical damage (dents, gouges), pipe deformation caused by soil movement or floods, etc.

c) Inherent factors, including seam welds, mill defects, girth weld defects, buckles or wrinkles, etc.