
**Petroleum and natural gas industry —
Pipeline transportation systems
— Pipeline integrity management
specification —**

**Part 1:
Full-life cycle integrity management
for onshore pipeline**

PNGI — Spécifications de gestion de l'intégrité des pipelines —

*Partie 1: Gestion de l'intégrité des pipelines terrestres durant leur
cycle de vie complet*





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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 2, *Pipeline transportation systems*.

A list of all parts in the ISO 19345 series can be found on the ISO website.

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.

Introduction

This document addresses the integrity of petroleum and natural gas pipelines through their entire life-cycle, from design to eventual abandonment. For this reason, considerations relating to design, construction and abandonment have been included. This approach supports the development and implementation of a holistic and integrated pipeline integrity management program that bridges between life-cycle elements and thereby avoids compartmentalizing of the pipeline life-cycle into essentially independent data and functional silos, which traditionally has been the case.

The integrated approach was developed on the basis of extensive research and examination of best practices and results from pipeline integrity audits world-wide. This document incorporates a combination of prescriptive and performance-based requirements. In some cases where there are prescription requirements, it provides the user the option to arrive at a solution using performance-based requirements. However, the level of safety achieved by following the prescriptive requirements gives the minimum performance-based requirements. The ability to use performance-based solutions allows companies to use new equipment or innovative practices to achieve the same goal.

This document is intended to be used by companies that have not yet developed an official program or are developing a program for new pipelines. This document can also be used for continual improvement of existing programs by both operating companies and regulators to evaluate integrity management program effectiveness.

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

Part 1: Full-life cycle integrity management for onshore pipeline

1 Scope

1.1 This document specifies requirements and gives recommendations on the management of integrity of a pipeline system throughout its life cycle which includes design, construction, commissioning, operation, maintenance and abandonment.

1.2 This document is applicable to onshore pipeline systems used in transportation in the petroleum and natural gas industries, 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 purposes. The extent of pipeline systems covered by this document is illustrated in [Figure 1](#). This document does not deal specifically with the integrity of non-pipe elements. The pipeline segment between the wellsite and the gathering station, treatment plant or process plant (between Facilities 1 and 2 in [Figure 1](#)) is included in this document, though many mandatory elements of this document are not practical due to characteristics such as diameter, operating parameters, etc.

1.3 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.

1.4 This document does not cover all conditions nor engineers' competency which might be related to pipeline integrity. The user can evaluate whether additional requirements are necessary.

1.5 This document is used for integrity management, which is initiated at the design and construction stage of the pipeline. Where requirements of a design and construction standard (e.g. ISO 13623) are

different, the provisions of this document will enhance the design and construction from an integrity perspective.

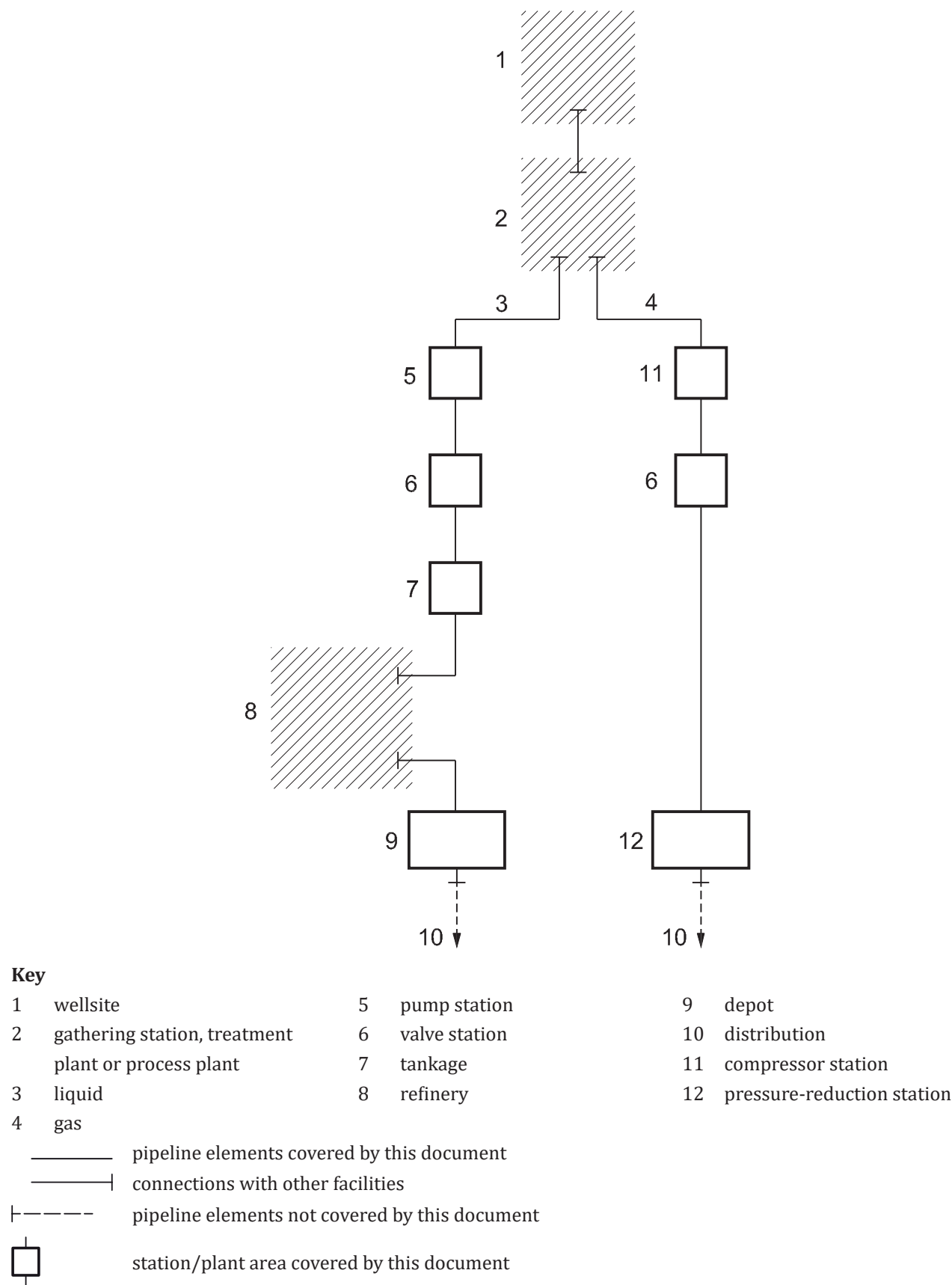


Figure 1 — Extent of pipeline systems covered by this document

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 13623, *Petroleum and natural gas industries — Pipeline transportation systems*

ISO 15589-1, *Petroleum, petrochemical and natural gas industries — Cathodic protection of pipeline systems — Part 1: On-land pipelines*

ISO 21809 (all parts), *Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems*

ISO 31000, *Risk management — Guidelines*

IEC 31010, *Risk assessment techniques*

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 terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1.1

abandonment

activities associated with taking a pipeline permanently out of operation

Note 1 to entry: An abandoned pipeline cannot be returned to operation.

Note 2 to entry: Depending on the legislation abandonment can require cover or removal.

3.1.2

anomaly

possible deviation from pipe material or weld soundness

Note 1 to entry: The identification of an indication of an anomaly can be generated by non-destructive inspection, such as in-line inspection.

3.1.3

baseline assessment

first integrity assessment prior to or after commission

3.1.4

cathodic protection

corrosion control technique to prevent or reduce the external corrosion of metal pipelines by transferring an electrical current onto the pipe to achieve increased negative electrical potentials

3.1.5

corrosion

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

3.1.6

crack

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

3.1.7

critical consequence area

location where a pipeline release might have a significant adverse effect on public safety, property and the environment

Note 1 to entry: The location and scope of critical consequence areas will change over time as new population and environmental resource data becomes available. The pipeline segments in CCAs are of particular interest in risk assessment and integrity assessment evaluations and prioritizations.

3.1.8

deactivation

removal of a pipeline from service though the pipeline might be returned to service after a proper assessment

Note 1 to entry: Also defined as decommissioning or suspension.

3.1.9

deformation

change in shape of the pipe or component, such as a bend, buckle, *dent* ([3.1.11](#)), 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

3.1.10

defect

imperfection of a type or magnitude exceeding acceptable criteria

3.1.11

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

3.1.12

design life

period for which the design basis is planned to remain valid

[SOURCE: ISO 13623:2017, 3.1.2]

3.1.13

external corrosion direct assessment

integrity assessment process used for locating possible external corrosion, damaged coating, or deficiencies in *cathodic protection* ([3.1.4](#)) on a pipeline by making aboveground measurements and validating with excavations to examine the pipe where appropriate

3.1.14

failure

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

3.1.15

fitness for purpose

quantitative engineering evaluation that is performed to demonstrate the structural integrity of an in-service component that can contain an imperfection, *defect* ([3.1.10](#)) or damage

3.1.16

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

3.1.17**hard spot**

localized increase in hardness through the thickness of a pipe, produced during hot rolling or welding

3.1.18**incident**

unintentional release of gas or liquid due to the *failure* (3.1.14) of a pipeline

Note 1 to entry: Some regulatory authorities define “incident” as an event occurring on a pipeline for which the operator is required to make a report to the concerned regulatory authority.

3.1.19**in-line inspection**

inspection of a pipe wall from the interior of the pipe using specialized tools

3.1.20**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

3.1.21**integrity management program**

documented program that specifies the practices used by the operating company to proactively manage the safe, environmentally responsible and reliable service of a pipeline system throughout its lifecycle and which incorporates a continuous improvement process

3.1.22**life extension**

additional period of time beyond the original design or *service life* (3.1.39) (but within the assessed remnant life) for which permission to continue operating a pipeline system is granted by the regulatory bodies

Note 1 to entry: Life extension is considered as a modification to the design basis.

[SOURCE: ISO/TS 12747:2011, 3.7]

3.1.23**location class**

geographic area classified according to criteria based on population density and human activity

[SOURCE: ISO 13623:2017, 3.1.10]

3.1.24**magnetic flux leakage**

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 wall. The magnetic flux leakage pattern is used to detect and characterize anomalies.

3.1.25**management of change**

process that systematically recognizes and communicates to the necessary parties changes of a technical, physical, procedural, or organizational nature that can impact system integrity

3.1.26**manufacturing defect**

defect (3.1.10) in the pipe body or coating created during the pipe or component manufacturing or coating processes

3.1.27

maximum allowable operating pressure

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).

3.1.28

metal loss

pipe 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.

3.1.29

non-destructive testing

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.

3.1.30

operator

person or organization who owns or operates a pipeline system or facilities and is ultimately responsible for the operation and integrity of the pipeline system

3.1.31

pipeline

components of a pipeline system connected together to convey fluids between stations and/or plants, including pipe, launchers and receivers, components, appurtenances, isolating valves, and sectionalising valves

3.1.32

pipeline integrity management

set of processes and procedures that proactively assures incident-free safe and environmentally responsible transportation of fluids through a pipeline system

3.1.33

pipeline integrity management program

continuous improvement closed-loop system using information technology to realize functions such as data acquisition and integration, integrity and *risk assessment* ([3.1.36](#)), mitigation and repair activity and maintenance decisions, with comprehensive management of change and continual review and improvement processes

3.1.34

pressure test

means of assessing the integrity of a new or existing pipeline that involves filling the pipeline with water and pressurizing to a level in excess of the MAOP of the pipeline to demonstrate that the pipeline is fit for service at the MAOP for a given time frame dependent on the identified integrity hazards

Note 1 to entry: See ISO 13623:2017, 6.7.

3.1.35

risk

measure of loss, either qualitative or quantifiable, in terms of both the likelihood of incident occurrence and the magnitude of the consequences of the incident occurrence

3.1.36

risk assessment

systematic, analytical process in which potential hazards from pipeline system are proactively identified, and the likelihood and consequences of potential adverse events are determined

3.1.37**risk management**

coordinated activities to direct and control an organization with regard to *risk* ([3.1.35](#))

[SOURCE: ISO Guide 73:2009, 2.1]

3.1.38**safe operating pressure**

pressure, calculated using the appropriate analysis and mathematical formulas for the specific type of defect identified

EXAMPLE For corrosion defects, using recognized remaining strength of corroded pipeline formulas, where all corroded regions will withstand a calculated safe operating pressure.

3.1.39**service life**

length of time over which the pipeline system is intended to operate

[SOURCE: ISO/TS 12747:2011, 3.21]

Note 1 to entry: Service life is considered the actual operational life to date, but can include any planned future use of the line. Service life can be less or longer than design life.

3.1.40**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 $\pm 10\%$ of the wall thickness (the tolerance) and 80 % of the time (the certainty).

3.1.41**third party damage**

damage done to the pipeline as a result of activities by personnel not associated with the pipeline

3.1.42**threat**

activity or condition that can adversely affect the pipeline system if not adequately controlled

[SOURCE: ISO/TS 12747:2011, 3.23]

3.2 Abbreviated terms

AC	alternating current
CP	cathodic protection
CCA	critical consequence area
CoF	consequence of failure
DA	direct assessment
ECDA	external corrosion direct assessment
GIS	geographic information system
HIC	hydrogen-induced cracking
ICDA	internal corrosion direct assessment

ILI	in-line inspection
IMP	integrity management program
MAOP	maximum allowable operating pressure
MFL	magnetic flux leakage
NDT	non-destructive testing
PIR	potential impact radius
PoF	probability of failure
SCADA	supervisory control and data acquisition system
SCC	stress corrosion cracking
SCCDA	stress corrosion cracking direct assessment
SMYS	specified minimum yield strength
SSC	sulphide-stress cracking

4 General

4.1 Key principles

The operator uses integrity management programs (IMPs) to enable it to manage its pipeline systems in a safe, environmentally responsible and reliable manner. An effective IMP anticipates and mitigates or eliminates integrity issues before they lead to incidents or failures.

Key principles for an effective IMP are listed below.

- a) Pipeline integrity requires a lifecycle approach from initial feasibility studies to abandonment.
- b) Adequate resources in terms of funds, equipment and competent personnel to implement the requirements of the IMP are necessary.
- c) Clearly defined roles and responsibilities with clear communication processes are necessary.
- d) Document management including gathering and retention requirements are critical elements that enable informed decisions.
- e) Performance measures of the IMP's effectiveness should include both leading and lagging indicators to identify trends and areas for continuous improvement.
- f) An effective IMP uses risk-based decisions to prioritize integrity-related activities.

4.2 Integrity management program

4.2.1 General

The IMP forms part of a comprehensive asset management system operating alongside safety and environmental programs. The operator shall establish, implement and maintain a documented IMP and routinely review and improve its adequacy.

To facilitate the development and implementation of the initial IMP for pipeline systems, the operator shall develop processes for initial data acquisition, threat and consequence identification and risk

assessment at the design stage. The initial IMP will be updated and improved throughout the lifecycle of the assets.

4.2.2 Introduction to integrity management program elements

The pipeline IMP shall address the operator's approach to the following elements, see [Figure 2](#).

a) Life cycle phases for integrity management

Integrity shall be applied through the entire life cycle of pipeline, including:

- 1) feasibility;
- 2) design;
- 3) procurement;
- 4) fabrication;
- 5) transportation and storage;
- 6) construction;
- 7) pre-commissioning and commissioning;
- 8) handover;
- 9) operation and maintenance;
- 10) modification;
- 11) suspension/abandonment.

b) Pipeline integrity management process

As part of the continuous improvement process, the inputs into these elements shall be routinely updated, as required, to reflect the dynamic nature of pipeline systems:

- 1) data management (data acquisition, review and integration);
- 2) risk assessment (threat, consequence, probability, CCA);
- 3) inspection;
- 4) integrity assessment;
- 5) mitigation activity;
- 6) performance measurement and improvement.

NOTE 1 Understanding the pipeline's integrity and threats in the context of the surrounding environment is key to making informed integrity management decisions.

NOTE 2 Performance measurement can verify that the goals, targets and objectives of the integrity program are being met and can be used during management reviews to identify improvement opportunities.

The following elements shall be developed for the operational phase to ensure that adequate management practices are in place to assess failures and manage and respond to emergencies:

- failure assessment plan;
- emergency response plan;
- remaining life assessment plan.

NOTE 3 The failure assessment plan considers failure causes and contributing factors and provides critical information to the IMP. The goal is to prevent recurrence of similar failures.

NOTE 4 The emergency response plan is designed to ensure the operator is prepared to deal with accidents and incidents in a timely manner to aid in the reduction of consequences. These accidents or incidents can occur because the IMP did not foresee or was unable to effectively mitigate the threat. Emergency response plans also include contingency repair plans and procedures.

NOTE 5 The remaining life assessment provides input into the economic viability assessment of the pipeline. As the pipeline ages, the operational risks and mitigation costs increase until continuing the operation is no longer viable.

c) Management elements

The following elements shall form part of an IMP and might be written to encompass more than one pipeline or system. These elements usually interact with other management systems within an organization:

- 1) policy and commitment;
- 2) scope of the IMP;
- 3) organizational structure including key roles and responsibilities.

The following mandatory elements predominately deal with information flow, providing the core of the data system providing information for assessment and review. They are usually presented as plans with procedures:

- communication;
- records and documents management;
- management of change;
- management review and audit;
- training and skills.

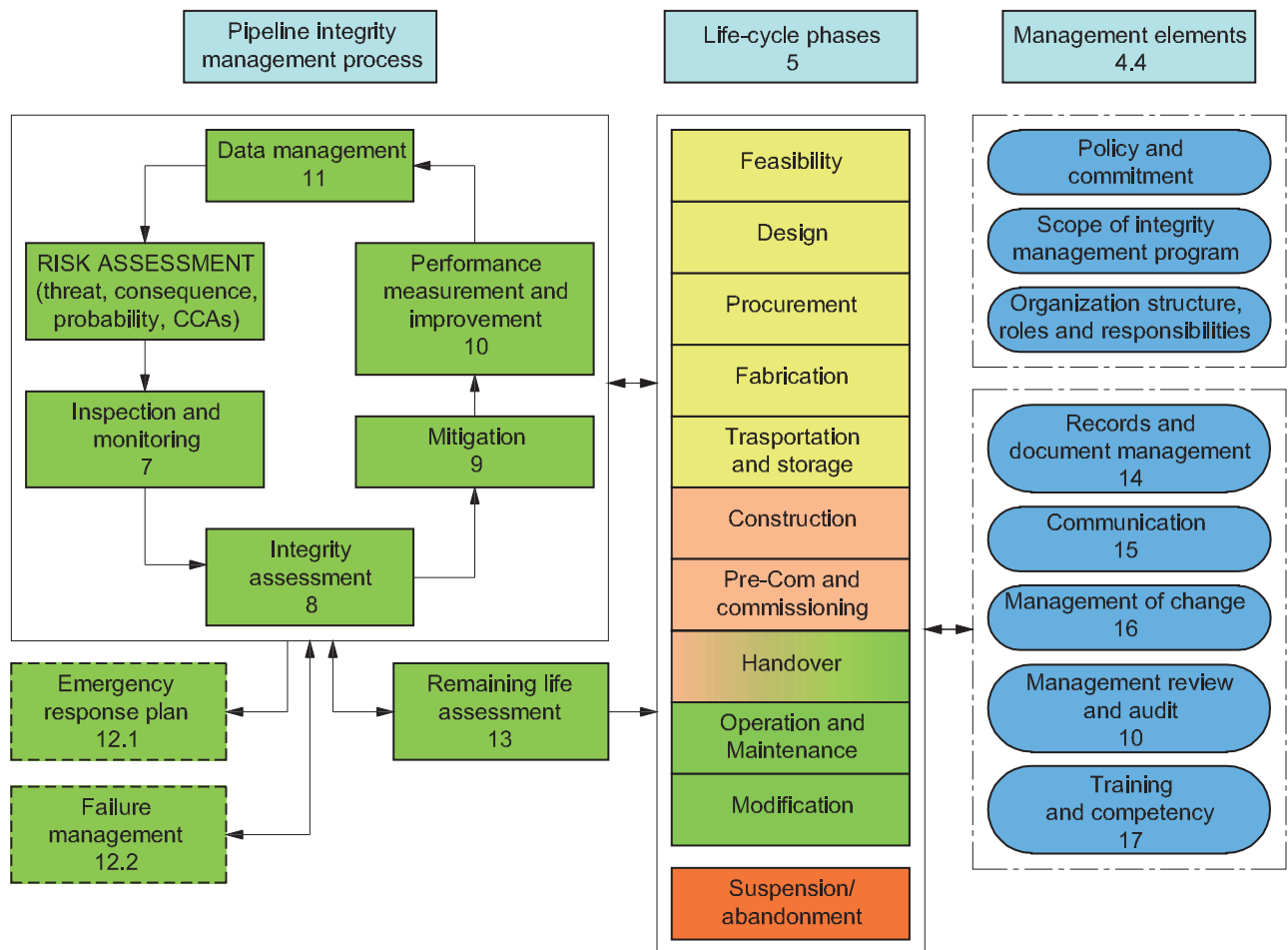


Figure 2 — Pipeline integrity management program structure

4.3 Integrity management process elements

4.3.1 Data management

The first step in evaluating the potential threats for a pipeline system or segment is to define and gather the necessary data and information that characterize the segments and the potential threats to that segment. A plan for collection of historical data shall be established and maintained for the pipeline system lifecycle. The operator shall perform the initial collection, review and integration of relevant data and information from pipeline design, construction, operation, maintenance, inspection, monitoring and failure investigation data. Data acquisition is needed to understand the condition of the pipe, identify the location-specific threats to its integrity and understand the public, environmental and operational consequences of an incident.

4.3.2 Risk assessment

Risk analysis is an analytical process through which the operator considers the likelihood of the threats occurring and the nature and severity of the resulting consequences.

Risk assessment shall be performed for all scenarios including low consequence—high likelihood and critical consequence—low likelihood events. Every plausible failure mode shall be listed and assigned probability and consequence values. Where multiple consequences occur from a single failure mode, multiple assessments are required.

The operator shall consider all the threats and any interactive threats that can be applicable to its system. It can be appropriate to consider risks in pipeline segments where the consequence of failure is particularly high and where explicit integrity management measures have to be implemented.

Completed risk assessment shall be reviewed at regular intervals and when substantial changes occur to the pipeline. The assumptions and variables used in the risk assessment shall be validated and updated, where applicable as part of the review.

4.3.3 Inspection and monitoring

The operator shall select and conduct appropriate inspection and monitoring based on the risk assessment made in the previous step, typically including in-line inspection, pressure testing, direct assessment or other inspection and monitoring methods based upon the threats that have been identified. More than one inspection or monitoring method can be required to address all the threats to a pipeline segment.

4.3.4 Integrity assessment

Integrity assessment will implement the following hierarchy of controls:

- elimination;
- physical controls;
- procedural controls.

Where risks cannot be sufficiently controlled, mitigation activities shall be implemented until the risk is considered satisfactory.

The process of establishing and implementing effective preventive and mitigation measures requires suitable data collection, data integration and informational analysis within the IMP. Data integration and the analysis can identify aspects of the operator's operations and maintenance that allow the operator to address the threats. Most importantly, local knowledge of the operational environment around the pipeline and the incident history associated with certain components or circumstances should be considered.

4.3.5 Mitigation activity

Where a threat cannot be controlled, the operator shall develop appropriate actions to mitigate the threat to an acceptable level of risk.

The results of mitigation assessments shall be used to determine what additional prevention or mitigation measures are required to reduce unacceptable risks identified in the assessment. Prevention and mitigation activities should be applied to reduce the likelihood of failure and/or the consequence of the failure to an acceptable level. Preventative measures typically involve activities to reduce the likelihood of an event.

The operator shall perform mitigation activities to ensure the pipeline system remains safe for its intended service. Where applicable, these mitigation activities shall provide a factor of safety that is notionally similar to the design factor of safety [e.g. achieved through an applicable hydrostatic strength (proof) test of the pipeline]. This notional equivalent design factor of safety shall be maintained throughout the life of the pipeline. The mitigation activities can include activities such as increased surveillance and pressure reductions.

4.3.6 Performance measurement and improvement

The operator shall develop procedures to regularly measure and evaluate the adequacy of implementation and effectiveness of IMP and its conformity to relevant standards.

The operator shall also evaluate the effectiveness of its other related management programs and processes in supporting integrity management decisions.

A combination of performance measures and system audits can be necessary to evaluate the overall effectiveness of a pipeline integrity system.

Performance measurement results shall be used to continuously identify areas for improvement of the IMP. In addition, advances in technology and industry best practices shall be considered.

4.3.7 Emergency response plan

Plans and response procedures for emergency situations shall be established and maintained based on a systematic evaluation of possible scenarios that can affect the safe and reliable operation of the pipeline system. Plans and procedures for contingency repair of the pipeline shall be established depending on the criticality of the pipeline system, based on factors such as safety, environmental, legislative or commercial considerations.

4.3.8 Failure management plan

The operator shall develop procedures for pipeline failure investigation to ensure that a structured approach is adopted and all aspects of a failure are reviewed. The failure investigation shall aim to determine the root cause and contributing factor of a pipeline failure and recommend corrective actions to prevent similar failures. This can include a targeted risk management program for causes that are not isolated. The operator shall setup a database to record relevant pipeline failure information to support failure management.

4.3.9 Remaining life assessment

The operator shall develop a remaining life assessment for all pipeline segments and systems and apply updates as new integrity information is gathered, e.g. ILI, or when the operational parameters change (e.g. pressure or temperature). The remaining life assessment shall be reviewed at regular intervals, such as at the end of the design life, after pipeline failures, or when changes in key operating design parameters occur.

The remaining life assessment will be used to enable lifecycle management processes to balance the risks of ongoing operation with safety and protection of the environment and associated costs of operations and management.

4.4 Management elements

4.4.1 Policy and commitment

The operator shall have a policy that expresses management commitment for developing, implementing, reviewing and continuous improvement of a pipeline IMP. The operator shall instruct personnel to meet its requirements.

4.4.2 Scope of integrity management program

The operator shall determine the scope of the IMP, including identifying the applicable pipeline systems and the goal and objectives of the IMP for the identified pipeline system.

The operator shall maintain a documented IMP that addresses the management of the pipeline integrity and specific treatment for all unacceptable risk.

4.4.3 Organization structure, roles and responsibilities

The operator shall have a clearly defined organizational structure to implement the IMP. Pipeline integrity management shall be carried out by personnel with clearly defined roles, responsibilities, authority and accountability in implementing and reviewing the IMP.

Where applicable, the organizational structure shall identify the linkages to other related management system programs, such as the safety and environmental programs.

The organizational structure should also take into account both upstream and downstream system inputs/outputs to ensure no changes in one system can have a negative effect on an adjacent system not within the control of the operator

4.4.4 Records and documents management plan

The IMP shall be documented and effectively updated. Program items to be documented shall include the following:

- documents and records needed by the operator to ensure the effective operation and control of its processes;
- statements of integrity management policy and objectives;
- procedures required by the implementation of integrity management.

A records and documents management plan shall be developed to facilitate the storing and retrieving of records and documents in a timely manner. The plan shall include means to confirm accuracy and quality of inputs.

4.4.5 Communication plan

A plan for reporting and communication to all stakeholders, including but not limited to employees, management, authorities, customers, the public, local officials and responders, shall be established and maintained.

4.4.6 Management of change plan

A systematic process shall be used to ensure that, prior to implementation, changes to the pipeline system product being shipped, design, operation or maintenance are documented and evaluated for their potential risk impacts and to ensure that changes are documented and evaluated.

4.4.7 Management review and audit plan

Management review and audit of the pipeline integrity management program shall be conducted at regular intervals to determine the adequacy, implementation and effectiveness of the integrity program. The focus of management reviews and audits shall be on evaluating the following:

- effectiveness and adequacy of the IMP to meet its stated goals and targets;
- implementation of the IMP;
- conformity to regulatory and operator's requirements;
- identification of corrective actions for continual improvement.

4.4.8 Training and competency plan

The IMP shall establish clear competency requirements for all roles involved in pipeline integrity management including operators, contractors, engineers and other persons using this document.

Training needs shall be identified and training shall be provided for relevant personnel in relation to management of pipeline integrity.

5 Integrity management for the pipeline lifecycle phases

5.1 General

5.1.1 Objectives

Pipeline system design (including material procurement and selection) and construction (including installation testing and commissioning) along with operations and maintenance activities have an impact on pipeline integrity.

Although these activities would follow recognized standards, it is important to realize that conformity to a minimum standard might not identify potential long-term integrity issues. Therefore, it is important to review pipeline risks at handover from each pipeline phase and throughout the integrity lifecycle.

Designers, procurers, constructors, operators and maintenance personnel and integrity management practitioners shall be aware of [5.3](#) that highlights the interrelation between the pipeline lifecycle phases (which entails includes components such as design, procurement, fabrication, construction, commissioning, operation and maintenance) and integrity. [5.3](#) identifies areas where changes in each of the pipeline lifecycle phases could be needed to aid in long term integrity management.

5.1.2 Principles

The following high-level principles shall be considered during each of the pipeline lifecycle phases.

- a) Risk-based approaches to integrity management shall be applied. [Clause 6](#) provides guidance on risk assessment methodologies.
- b) Functional requirements for integrity management shall be incorporated into each lifecycle phase.
- c) The concepts and requirements of IMP shall be regarded as the basis for long term asset management.
- d) Any deviations shall be reviewed to evaluate impacts on integrity.
- e) Pipeline segments shall be designed according to ISO 13623, or a similar standard, to accommodate ILI tools. Where ILI accommodation is not practical, e.g. short service life, short connections or off-takes, the operator shall identify an appropriate alternative integrity assessment method.
- f) Data is regarded as the foundation of a pipeline integrity management and the operator shall have a comprehensive plan for collecting, managing, retrieving and analysing all data sets.

5.2 Key lifecycle integrity processes

Integrity assessment is an ongoing process that utilizes data from the various pipeline lifecycle phases to enable the operator to determine the integrity or soundness of the pipeline for its continued operation or design purpose.

The integrity assessment process for new pipelines utilizes construction inspection data and for operating pipelines utilizes data from pipeline condition monitoring activities, such as ground movement monitoring, ILI, DA and pressure test to identify threats. After all the threats are identified, they are evaluated and characterized, in some cases by excavating and in-situ measurements. The potential consequence and likelihood of identified threats are further evaluated using the appropriate method to determine fitness for purpose that includes a notional factor of safety. The operator shall determine the appropriate integrity assessment methods based on the threat and the capabilities and limitations of the integrity assessment method.

An integrity assessment can be conducted to evaluate the risk and the interval for the next integrity assessment shall be determined based on the findings.

For pipelines already in operation, an integrity assessment shall be completed within 3 years if no previous integrity assessment has been performed.

5.3 Lifecycle phases for integrity management

5.3.1 General

Integrity management occurs throughout the whole lifecycle of an asset from the initial feasibility studies through to abandonment and heavily influences the design considerations and the ongoing maintenance/management techniques.

All threats to the integrity of the asset shall be identified and controlled throughout the lifecycle; therefore, the elimination of the threats by improvements in design can provide a significant advantage to the on-going safe and reliable operations of the pipeline.

Each of the lifecycle phases has opportunities to mitigate or control integrity threats and each life cycle phase shall be adequately designed and controlled to optimize the integrity oversight.

The personnel responsible for each lifecycle phase should be familiar with basic pipeline integrity issues and concepts. In addition, a process shall be developed where the pipeline integrity subject matter experts will review each lifecycle phase to determine if there are potential pipeline integrity issues that need resolution.

5.3.2 Feasibility

5.3.2.1 Objectives

At the feasibility phase of the integrity management lifecycle, the key integrity risks are associated with the physical attributes of the route. Proactive avoidance of threats is a critical design objective and action at this phase in the lifecycle can provide significant benefits during construction. This could reduce the level of future mitigation being applied throughout the pipeline lifecycle, leading to improved reliability and reduced operating cost.

5.3.2.2 Principles

At this phase in pipeline development, the basic route selection is often a straight line between supply and delivery points. Modifying the route would typically increase the overall pipeline length but reduced operation and maintenance costs can warrant the increased construction cost.

Optimized routing can take into account many of the key potential threats by avoiding obvious difficulties during construction. Improved routing to avoid geographic features such as mountainous terrains, permafrost, major rivers, flood plains and swamp zones can provide significant construction improvements. Other considerations at this phase include access to the pipeline for pressure test activities and pipeline drying. In addition areas of critical consequences associated with safety of the public or damage to the environment would be avoided.

Realistic route selection at this phase will improve the cost estimates for the proposal, enabling more realistic evaluation of the project costs.

5.3.3 Design

5.3.3.1 Objectives

At the design phase, all of the integrity threats that the pipeline system will be exposed to during its lifetime are anticipated. The operator shall also anticipate future land use activities and encroachment

that can lead to elevated consequences and a change in the original risk profile or have a direct impact on pipeline integrity, due to third party damage. In addition, the pipeline designer should consider designing the pipeline to enable condition monitoring of the pipe wall using applicable inspection technologies such as ILI.

5.3.3.2 Principles

At the design stage, CCAs analysis shall be implemented using the methods stated in [6.6.2](#) or other equivalent methods. Routing selection shall be optimized to avoid CCAs where practical. Where rerouting is not feasible, mitigation measures shall be adopted.

To confirm that suitable physical and procedural protective methods have been implemented, pipeline segments, especially CCAs, shall be validated including consideration of future changes to the environment, e.g. future urban growth, rezoning.

Where special construction methods or processes are utilized, they shall be assessed to determine any impact on future integrity and necessary mitigation that might be required.

5.3.4 Procurement

5.3.4.1 Objectives

At the procurement phase of the integrity management lifecycle, the key integrity risks are associated with meeting the quality and functionality of the materials detailed by the designer. Proactive avoidance of inappropriate or defective material at this phase in the lifecycle can reduce the risks associated with failure during testing and operation.

In the operating phase, poor procurement decisions can lead to substandard equipment reducing functionality or safety and can be significant to the economic performance of the assets.

5.3.4.2 Principles

At this phase in the lifecycle, the quality of the final asset can be directly related to the material supplied. During design, specific materials will have been selected for the required operation envelope and might have been specified to deal with the risk from identified threats. Failure to obtain the desired material quality during procurement could lead to substandard materials being installed which could introduce integrity threats to the pipeline. Data management during procurement is essential to facilitate verification of the material received and its source and specification to ensure they meet the design specifications. These records shall be maintained throughout the life of the asset.

5.3.5 Fabrication

5.3.5.1 Objectives

At the fabrication phase of the integrity management lifecycle, the key integrity risks are associated with poor quality in the fabrication processes and not meeting design specifications.

5.3.5.2 Principles

At this phase in the lifecycle, the quality of the final asset can directly relate to the fabricated items and its dimensional tolerances. Where fabricated items are incorrectly built, this could lead to long term operational and integrity threats.

5.3.6 Transportation and storage

5.3.6.1 Objectives

At the transportation and storage phase of the integrity management lifecycle, the key integrity risks are associated with pipeline components suffering damage and no longer being suitable for construction or fit for purpose.

5.3.6.2 Principles

At this phase in the lifecycle, the quality of the final asset can be directly impacted by the transportation and storage of each of the pipeline system components such as pipe, coating and fittings. Care is required during handling and storage techniques shall be suitable for the items being handled to ensure that they do not sustain impact and are correctly stored to protect against environmental damage. Appropriate handling techniques shall be designed specified and used with correctly designed storage facilities.

Any delays that can impact pipeline integrity during transportation and storage shall be reviewed and their potential impact on the pipeline materials assessed and mitigated.

5.3.7 Integrity during construction

5.3.7.1 Objectives

At the construction phase of the integrity management lifecycle, the key integrity risks are associated with failing to build the asset to the specification laid down by the designer.

5.3.7.2 Principles

At this phase in the lifecycle, the quality control of the construction works and records management are the key aspects for management activities. Failing to build the asset to the design specifications and standards for valid reasons shall be managed and assessed on a case-by-case basis. Construction re-work and even the repair of major defects developed during construction can significantly increase both the time line and costs for construction.

In all cases, management of change will be required to confirm the suitability of any design changes and can require adjustment to the arrangements for ongoing integrity and reliability. Risk assessments shall be carried out to identify any necessary mitigation adjustments to the IMP.

As-built documentation shall reflect the exact details of the final build to ensure that integrity issues in future years can be investigated without requiring excavation/inspection.

In the event of any change in the route during the construction phase, CCAs shall be re-identified and re-assessed for the design optimization. Relevant information shall be updated from time to time in the event of any change to pipeline segmentation identified during the construction phase.

5.3.8 Pre-commissioning and commissioning

5.3.8.1 Objectives

At the pre-commissioning and commissioning phases of the integrity management lifecycle, the key integrity risks are associated with failing to design and implement appropriate procedures during the pressure test which might lead to insufficient testing or in an extreme case damage to the pipeline and/or its coating from excessive strain. Additional integrity issues might arise from incomplete cleaning, drying, purging, or preservation prior to start-up.

5.3.8.2 Principles

The pre-commissioning and commissioning phases require an appropriate checking and proving procedure. Significant damage can be caused to the asset from incorrect testing and the personnel shall be aware and conform to the detailed requirements.

Pressure testing has the potential to impact safety and the environment, therefore a pressure testing plan shall be developed and a risk assessment shall be completed. During testing all pipeline sections will undergo strain to different extents and a testing procedure shall be developed to ensure that lower lying sections of pipe (where hydraulic weight adds to the strain being applied) do not fail. The risk assessment shall examine the potential consequences associated with a pressure test such as worker safety and failures. In addition, contingency plans shall be put into place in the event of a pipeline failure during the pressure testing.

Gauging is an important check to verify the geometric condition of the pipeline. It can be used to detect dents and other deformations in pipeline.

Data records and retention of the records of the pressure testing are critical requirements that demonstrate initial safety of the pipeline and provides a degree of ongoing proof of ongoing safety, particularly where future changes to operating pressure are being considered and pipeline defects are being assessed.

Following pressure test, the pipeline shall be protected from all threats regardless of whether it has been fully pressurised. Surveillance and lands processes shall commence.

5.3.9 Handover — Preparation for operation

5.3.9.1 Objectives

At the handover phase of the integrity management lifecycle, the pipeline systems are implemented to ensure that key integrity threat mitigation is adequate and records are retained.

5.3.9.2 Principles

Operation personnel and integrity management practitioners shall be informed of any mitigation aspects built into the design of the pipeline including the interrelation between any particular integrity aspects built into the operational activities and the resultant integrity control.

The following principles shall be considered.

- All data collected from the design, fabrication, construction and commissioning phase shall be gathered, maintained and updated throughout the life of the pipeline. The constructor shall provide full design, construction and “as-built” documentation in a format to suit the operator.
- Construction design requirements to ensure pipeline integrity shall be incorporated into the pipeline operating procedures and shall be maintained.
- At this phase the operator shall review all records for completeness and data quality and shall ensure the necessary records are preserved for the life of the asset. Storage methods shall utilize electronic systems where possible, while taking into consideration the impact of future changes to computer operating systems and programs.
- All inspection data (visual, NDT and ILI) obtained during the construction and testing phases shall be evaluated in a baseline assessment. Imperfections that are acceptable based on relevant construction specifications and standards, shall be evaluated to determine their suitability for long term operations. The baseline assessment data is one of the inputs used in the IMP once the pipeline system placed into operation.
- Designed threat mitigation shall be reviewed to ensure that the pipeline risks have been adequately considered and all necessary threat mitigation implemented. Assumptions regarding pipeline

segments within the critical consequence areas shall be validated and confirmed prior to the commissioning stage. If changes or variances are identified, the risk assessment and treatment of the CCA shall be updated and this might include commissioning plans that consider CCAs and safety during the commissioning phase.

- The operator shall review/determine the planned maintenance requirements for new pipeline assets and schedule the maintenance into a documented maintenance system.
- Where GIS is being used, the data shall be uploaded within a suitable timeframe to enable integrity management practices to commence.

5.3.10 Operation and maintenance

5.3.10.1 Objectives

Pipeline system operation and maintenance activities can directly impact pipeline integrity. Thus, all activities executed on or in the vicinity of a pipeline, either by third party companies or the operator itself, shall be adequately designed and controlled throughout the operational phase to ensure that integrity is not compromised.

Integrity management during operation shall primarily be pro-active to prevent damage and failure incidents. The operator shall put in place an adequate organization to gather all relevant changes from the original data used for the first integrity assessment. Potential issues shall be identified to enable consideration of any necessary mitigation activities for every risk and threat during the operational period.

5.3.10.2 Principles

The following principles shall be considered for pipeline operation and maintenance.

- The operator shall be adequately resourced to monitor operational conditions to detect and assess any relevant changes impacting integrity on an ongoing process.
- Relevant changes in operation (pressure cycles, etc.) shall be assessed to identify any specific integrity threats.
- The impact of any deviation from operating procedures shall be recorded and assessed to identify any immediate or long-term implications to pipeline integrity.
- The operator shall collect sufficient data to perform threat analysis, consequence analysis and risk assessments. Implementation of the IMP will drive the collection and prioritization of additional data elements required to more fully understand and prevent/mitigate pipeline threats.
- Any threats to integrity and issues identified during operation shall be recorded and used to consider whether additional mitigation activities are required.
- Any change to the operating environment of the pipeline including land use shall be assessed and mitigated as necessary.
- Any incident during the operational period shall be recorded and mitigation against further instances shall be considered and implemented as necessary.
- The performance/efficiency of the IMP shall be reviewed periodically using key performance indicators (KPIs).

5.3.11 Modifications during operation

5.3.11.1 Objectives

During operation, pipelines might be modified for various reasons, such as lowering the pipe to accommodate roads, raising the pipe to allow for drainage works, adding branches, etc. These modifications might employ different processes design specification and standards from the original design. For example, the modifications can use different material grades and thickness, construction and joining techniques and coating. Modifications also include changes to the original design basis or production or operating parameters such as production fluid, flow rate, pressure, or temperature. These modifications shall be evaluated and shall be managed, relevant to integrity, in accordance with procedures applied to a new construction.

5.3.11.2 Principles

Modified pipelines shall be designed appropriately utilizing similar processes used for a new pipeline to ensure that any adverse change to threat levels are eliminated or avoided where possible. New or changed threats and/or consequences shall be documented and mitigated.

Pipeline as-built drawings and abandonment details shall be stored and maintained in association with the original records and all existing drawings and drawing systems updated as necessary.

5.3.12 Abandonment

5.3.12.1 Objectives

When a pipe is abandoned in place and not removed, the abandoned sections shall be appropriately decommissioned such that they are left in a condition that is safe for the public and the environment.

5.3.12.2 Principles

When a pipe is abandoned in place and not removed, the following shall be considered:

- internal grouting, such as sand slurry;
- sectioning with concrete (or similar) to avoid internal water filling tunnelling and transfer along the asset;
- assessing the surface impact of pipe wall collapse;
- positive isolation and disconnection from existing operating assets;
- retaining CP on the asset;
- maintaining signage.

6 Risk assessment

6.1 Definition of objectives and requirements

6.1.1 General

Risk assessment shall be applied throughout the entire pipeline lifecycle to identify and quantify risk to enable identification and prioritization of mitigation activities. There are several approaches to pipeline risk assessment that range from a qualitative to a quantitative risk approach. The operator can choose any model that supports its objectives and meets regulatory requirements, while still meeting a minimum level of technical justification. The approach should be selected according to data sufficiency and objectives of the assessment. [Annex A](#) shows an example of a semi-quantitative approach.

The outcome of a risk assessment should be presented in terms of likelihood and consequence, the categories for which shall be defined in quantitative terms where possible. An example of likelihood and consequence is shown in a risk matrix in [Annex B](#).

If the pipeline system information is insufficient or very limited, conservative assumptions on the system conditions shall be taken into account.

6.1.2 Objective

The objectives of a risk assessment for an IMP should include:

- a) identification of the threats to pipeline integrity;
- b) determination of the probability (likelihood) of failure (PoF) for each plausible threat;
- c) determination of the consequence of failure (CoF) for each plausible threat;
- d) determination of the risk represented by PoF and CoF;
- e) prioritization of segments of a pipeline system in the order of risk level (risk register);
- f) risk reduction through mitigation (see [Clause 9](#)).

A typical risk assessment process follows the flowchart in [Figure 3](#).

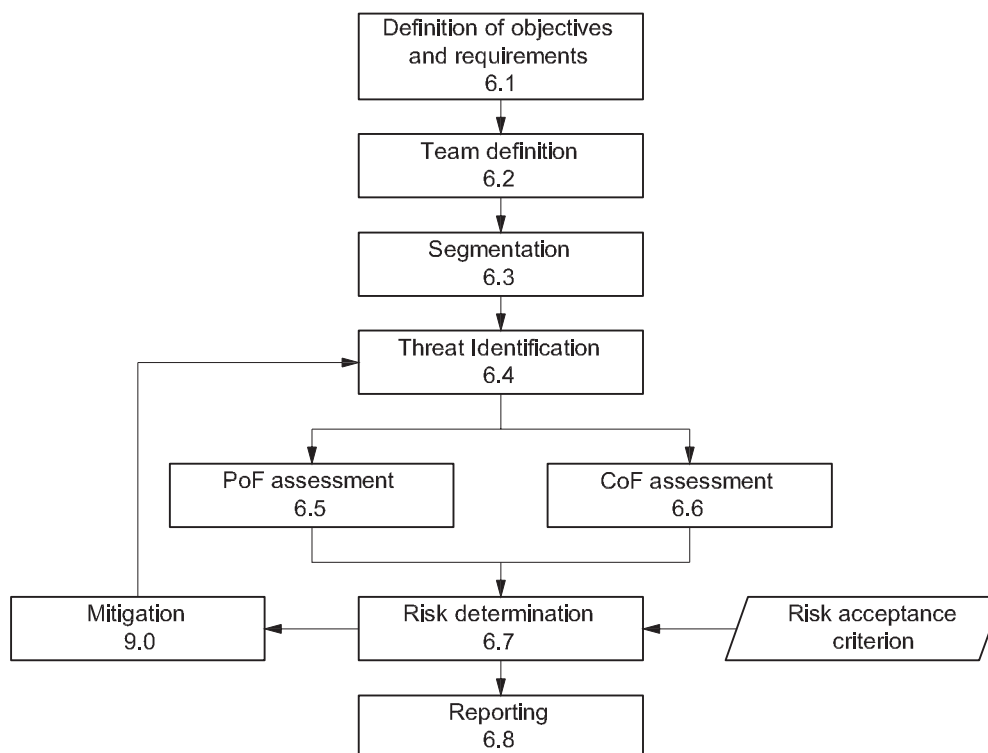


Figure 3 — Risk assessment process

6.1.3 Requirements

The risk assessment approach shall conform to ISO 31000 and IEC 31010 and should consider the following parameters.

- a) Assessment parameters – The risk assessment defines ‘failure’ and produces verifiable estimates of failure potential. The probability of failure is the likelihood of the full failure potential occurring,

not just that of an event occurring. Therefore, the risk assessment produces related measures of probability of failure and potential consequence.

- b) Integrate pipeline knowledge – All plausible failure modes and mechanisms are to be included in the assessment of the probability of failure. The risk assessment integrates all available risk knowledge from each of the lifecycle phases, but especially lessons learned from operation and maintenance and any issues discussed and/or resolved under management of change.
- c) Quantify data uncertainty – It is important to know the level of uncertainty of all input parameters. It is acceptable to use data with high uncertainty; however the risk assessment methodology should mitigate this uncertainty and show its effect on the final risk results. Black-box models should be avoided where possible to ensure a good understanding of the mechanism behind the results.
- d) Fully characterize consequences of failure – The risk assessment identifies and acknowledges the full range of plausible failure scenarios. The consequences of all scenarios, no matter how unlikely, should be quantified. Any interaction or overlap of threats should be taken into account.
- e) Produce risk profiles – The risk assessment shall produce a continuous profile of risk levels along the pipeline. The risk assessment might segment the pipeline where risks are essentially the same to provide a simplified review of the pipeline profiles.
- f) Control the bias – The risk assessment shall generate transparent results. The assessment shall be free of inappropriate bias that might lead to incorrect conclusions.
- g) Appropriate aggregation – Summaries of the risks presented by multiple segments is desirable. Guidance of segmentation can be found in [6.3](#). Aggregation of risk shall be utilized to avoid simple statistics that can mask the real risks presented by the segments.

6.2 Team definition

Risk assessments shall be carried out by a group that includes competent and experienced representatives of those responsible for operating, maintaining and managing the pipeline system. They shall have adequate knowledge of the system to be able to determine accurate PoF and CoF and to be able to define practicable mitigation measures. It is important to involve those who will be responsible for the various disciplines during operations, (or alternatively the relevant technical authorities), in the design risk assessment cycle to ensure that they agree with the assessment of risk and the practicality and effectiveness of proposed operational mitigations.

6.3 Segmentation

The segmentation of a pipeline allows for a clear understanding of the presence of threats in order to identify the likely damage processes and to establish the most likely consequence scenarios.

The pipeline system shall be divided into segments based on pipeline characteristics and the characteristics of the area through which the pipeline passes. The choice of segments shall be such that PoF and CoF can be considered to be uniform within each segment.

Along the length of each segment, the following items shall be uniform, e.g.:

- a) pipeline properties, e.g. diameter, wall thickness, coating type;
- b) threats;
- c) most likely consequence scenario, e.g., population density and environmentally sensitive areas.

An example of segmentation for a pipeline system is shown in [Figure 4](#).

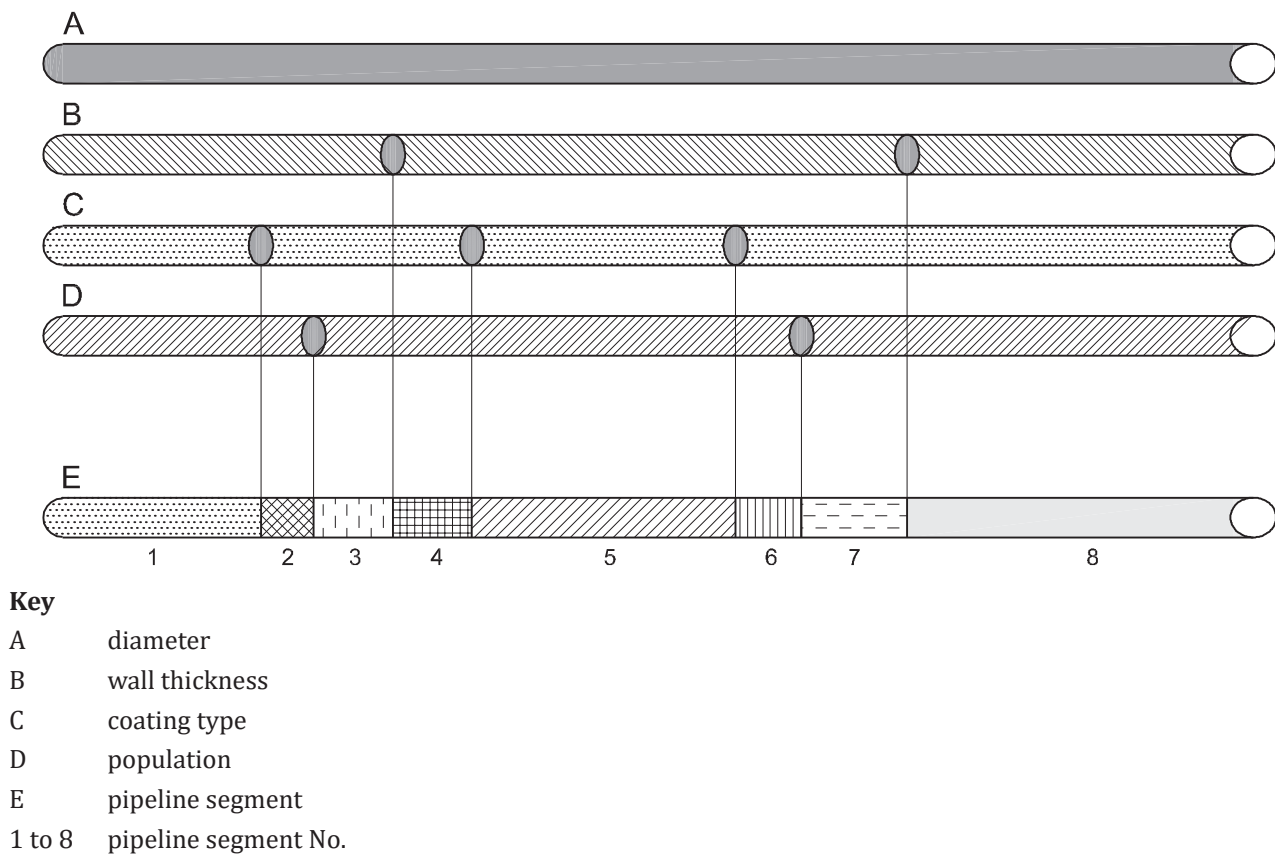


Figure 4 — Example of pipeline segmentation

6.4 Threat identification

Threats to the integrity of the pipeline shall be regularly identified throughout the service life of the pipeline. In addition, threats shall be determined based on an analysis performed at each lifecycle phase. Identification of potential or known threats for each lifecycle phase can be based on data obtained through a pipeline lifecycle quality assurance process that utilizes quality control data such as design and data reviews and inspections conducted throughout the lifecycle. In addition, potential or known threats can be identified based on an analysis of industry-wide pipeline failure history and operation of similar pipeline systems. Processes such as hazard identification (HAZID) study and failure tree analysis (FTA) can also be used as an input to the threat identification.

The following list illustrates typical pipeline lifecycle phases:

- a) feasibility;
- b) design;
- c) procurement;
- d) fabrication;
- e) transportation and storage;
- f) construction;
- g) pre-commissioning and commissioning;
- h) handover;
- i) operation and maintenance;

- j) modifications;
- k) decommissioning/suspension/abandonment.

[Table C.1](#) in [Annex C](#) provides an example of threat categorization and associated causes of occurrence during each phase of the pipeline lifecycle.

6.5 Probability of failure assessment

The PoF shall be estimated for all plausible threats identified for each segment. If more than one failure mode is plausible for a given threat, the PoF shall be estimated for each failure mode.

The PoF can be estimated using industry-wide or company failure statistics, or by using a probabilistic analysis. The effects of existing mitigation measures shall be taken into account in the estimation of the PoF.

Where historical data are used for frequency analysis or for validation of frequency analysis conducted by other methods, the suitability of the data and its compatibility with the characteristics of the pipeline system being analyzed shall be considered.

In assessing the threat, the mechanism of the threat shall be considered. For example, the threat of “corrosion” can result from localized pitting or from uniform metal loss over a large area. Both will lead to different failure modes.

Interaction of threats and of the associated damage mechanisms shall be considered and taken into account in the PoF assessment.

The PoF can be expressed qualitatively or quantitatively. It can be expressed quantitatively on a collective basis (e.g. failures per year) or on a linear basis (e.g. failures per kilometre-year).

6.6 Consequence of failure assessment

6.6.1 Consequence assessment

The consequence of failure can be expressed in categories such as:

- impact on people (population density type of buildings, encroachment, etc.);
- impact on the environment (water bodies, environmentally sensitive area, etc.);
- impact on business (deferred production, reputation, societal effects, operations, repair, etc.).

The consequence assessment for each category shall be carried out by a competent specialist in that area. The consequence of failure shall be determined for each failure mode for each segment.

Estimation of the impact of the loss of containment shall take into account the following:

- a) nature of containment, e.g. gas or liquid, ignition, flammability, toxicity, reactivity, dispersion mode;
- b) pipeline properties, such as pipeline diameter, wall thickness, type of coating, pressure, etc.;
- c) pipeline topography and elevation profile;
- d) population density (potential impact radius) and environmentally sensitive areas, such as water bodies, etc.;
- e) failure mode, such as leak or rupture;
- f) presence of mitigating measures to restrict loss of containment, such as leak detection, use of remote operated isolation valves and emergency response plan;

g) possible consequences following a loss of containment, which can include:

- 1) pressure waves following fluid release;
- 2) combustion/explosion following ignition;
- 3) toxic effects or asphyxiations;
- 4) contamination of environment and assets.

Knowledge of the release mechanism and the subsequent behaviour of the released material enables qualitative or quantitative estimates to be made of the effects of the release at any distance from the source for the duration of exposure.

Appropriate methods of consequence analysis vary widely in extent and degree of detail, depending on the type of threat to be analyzed and the objectives of the assessment.

6.6.2 Critical consequence areas analysis

6.6.2.1 Critical consequence areas for liquid and gas pipelines

Critical consequence areas for liquid and gas pipelines can be categorized as shown in [Table 1](#).

Table 1 — CCAs-affected segments ranking

Pipeline medium	Item	Ranking
Liquid pipeline (category B in ISO 13623)	A class 5 location ^a .	Rank III
	A class 4 location ^a .	Rank III
	A class 3 location ^a .	Rank II
	A populated area means a place that contains a concentrated population, such as an incorporated or unincorporated city, town, village, or other designated residential or commercial area as according to local regulation and company policy irrespective of class location.	Rank I
	An unusually sensitive area such as an area of drinking water resource or ecological resource as according to local regulation and company policy irrespective of class location.	Rank III
	Environment sensitive area listed in 6.6.2.2.3 or according to local regulation and company policy irrespective class location.	Rank III
^a Class location is in accordance with ISO 13623. ^b For a pipeline not more than 305 mm in nominal diameter and operating at a MAOP of not more than 8,3 MPa, an area which extends 90 m from the centreline of the pipeline to the identified site. For a pipeline greater than 762 mm in nominal diameter and operating at a MAOP greater than 6,89 MPa, an area which extends 300 m from the centreline of the pipeline to the identified site. For a pipeline not described in above, an area which extends 200 m from the centreline of the pipeline to the identified site. ^c Class E liquid pipelines have the same consequences as a gas pipeline.		

Table 1 (continued)

Pipeline medium	Item	Ranking
Gas pipeline (category D, E ^c in ISO 13623)	A class 5 location ^a .	Rank III
	A class 4 location ^a .	Rank III
	A class 3 location ^a .	Rank II
	Any area that contains a high traffic road crossing with the pipeline as according to local regulation and company policy irrespective of class location.	Rank II
	Any area in a class 2 location where the potential impact radius is greater than 200 m and the area within a potential impact circle contains 20 or more persons; or any area in a class 2 location where the pipeline is within 300 m, contains 20 or more persons or as according to local regulation and company policy.	Rank I
	Any area in a class 2 location where the potential impact circle contains an identified site; or any area in a class 2 location where the pipeline is within 90 m, 200 m or 300 m, contains an identified site or as according to local regulation and company policy. ^b	Rank I
^a Class location is in accordance with ISO 13623. ^b For a pipeline not more than 305 mm in nominal diameter and operating at a MAOP of not more than 8,3 MPa, an area which extends 90 m from the centreline of the pipeline to the identified site. For a pipeline greater than 762 mm in nominal diameter and operating at a MAOP greater than 6,89 MPa, an area which extends 300 m from the centreline of the pipeline to the identified site. For a pipeline not described in above, an area which extends 200 m from the centreline of the pipeline to the identified site. ^c Class E liquid pipelines have the same consequences as a gas pipeline.		

All CCAs can be divided into three classes (see [Table 1](#)), such that class I represents less serious while class III represents most serious.

6.6.2.2 Definitions

6.6.2.2.1 Identified sites

Identified site means each of the following areas:

- An outside area or open structure that is occupied by 20 or more persons on at least 50 days in any 12-month period. (The days need not be consecutive.) Examples include but are not limited to beaches, playgrounds, recreational facilities, camping grounds, outdoor theatres, stadiums, recreational areas near a body of water, or areas outside a rural building such as a religious facility.
- A building that is occupied by 20 or more persons during at least 5 days a week for 10 weeks in any 12-month period. (The days and weeks need not be consecutive.) Examples include but are not limited to religious facilities, office buildings, community centres, general stores, or roller skating rinks.
- A facility occupied by persons who are confined, are of impaired mobility, or would be difficult to evacuate. Examples include but are not limited to hospitals, prisons, schools, day-care facilities, retirement facilities or assisted-living facilities.

6.6.2.2.2 Potential impact radius

Potential impact radius (PIR) means the radius of a circle within which the potential failure of a pipeline could have significant impact on people or property. PIR (for natural gas pipeline) is determined by [Formula \(1\)](#).

$$r = 0,0998 \sqrt{d^2 p} \quad (1)$$

where

- d is the pipeline outside diameter, expressed in millimetres (mm);
- p is the operating pressure, expressed in mega pascal (MPa);
- r is the radius of impact, expressed in metres (m);
- 0,099 8 is the factor for natural gas. This number will vary for other gases depending upon their heat of combustion. Other gases or rich natural gas shall use different factors.

The length of the critical consequence area extends axially along the length of the pipeline from the outermost edge of the first potential impact circle that contains either an identified site or 20 or more buildings intended for human occupancy to the outermost edge of the last contiguous potential impact circle that contains either an identified site or 20 or more buildings intended for human occupancy (see [Annex D](#)).

In a performance-based program, the operator can consider alternate models that calculate impact areas and consider additional factors, such as depth of burial, which can reduce impact areas.

6.6.2.2.3 Environmentally sensitive area

An environmentally sensitive area means a drinking water or ecological resource area that is unusually sensitive to environmental damage from a liquid hydrocarbons pipeline release. The IMP shall define environmentally sensitive areas for drinking water resources and ecological resources.

An environmentally sensitive area drinking water resource is defined in accordance with local laws, regulations and experience. The following list provides examples:

- a) the water intake for a community water system (CWS) or a non-transient non-community water system (NTNCWS) that obtains its water supply primarily from a surface water source and does not have an adequate alternative drinking water source;
- b) the source water protection area for a CWS or an NTNCWS that obtains its water supply from an aquifer and does not have an adequate alternative drinking water source;
- c) the sole source aquifer recharges area where the sole source aquifer is a karst aquifer in nature.

An environmentally sensitive area ecological resource is defined in accordance with local laws, regulations and experience. The following list provides examples:

- an area containing endangered species or ecological community;
- a multi-species assemblage area;
- a migratory water bird concentration area.

6.7 Risk determination

For risk assessment, the methodologies listed in IEC 31010 can be used. The probability and consequence shall be matched to the same failure mode. For example, if the consequence level is assigned on the basis of a leak, then the probability should be that of a leak, not merely the probability of the threat (e.g. corrosion) occurring. For quantitative methods, risk can be described by [Formulae \(2\)](#) and [\(3\)](#) for independent failure modes. For dependent failure modes, recourse should be made to more sophisticated models.

- a) For a single failure mode:

$$Risk_i = p_i \times C_i \quad (2)$$