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Pipeline transportation systems — Recommended practice for pipeline life extension

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Contents

Page

Foreword v

Introduction vi

1 Scope 1

2 Normative references 3

3 Terms and definitions 3

4 Symbols and Abbreviated terms 5

5 Life extension overview 6
5.1 General 6
5.2 Assessment process 6
5.3 Assessment requirements 8
5.4 Limitations on life extension 9
5.5 Pipeline system availability 9

6 Data compilation 10
6.1 General 10
6.2 Data 10
6.2.1 Original design 10
6.2.2 Operations data 11
6.2.3 Maintenance and inspection data 11
6.2.4 External data 12

7 Technical integrity of the pipeline system 12
7.1 General 12
7.2 PIMS review 13
7.3 Remediation requirements 13

8 Future threat identification 14
8.1 General 14
8.2 Generic threats 14
8.3 Threats specific to offshore pipeline systems 14
8.4 Threats specific to onshore pipeline systems 15

9 Life extension assessment 15
9.1 Risk assessment 15
9.1.1 Process 15
9.1.2 Use of risk assessment in life extension 15
9.1.3 Acceptability of risk 16
9.1.4 Risk management 16
9.2 Pipeline system design review 17
9.2.1 Design codes 17
9.2.2 Changes to the design basis 17
9.2.3 Additional data requirements 18
9.3 Assessment of remnant life 18
9.3.1 Corrosion assessment 18
9.3.2 Fatigue and flaw assessment 19
9.3.3 Remediation 20
9.4 Integrity management during extended life 20
9.4.1 PIMS 20
9.4.2 Inspection and monitoring 21
9.5 Regulatory requirements 21
9.6 Update of systems and procedures 21

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9.6.1 General 21
9.6.2 Emergency response procedures 21
9.6.3 Operations and safety systems 22
10 Life extension report 22
Bibliography 24

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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.

ISO/TS 12747 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*.

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Introduction

Within ISO/TC 67/SC 2 there has been a series of discussions concerning both the needs and level of prescription required to address pipeline life extension issues. These have highlighted that:

— operators are applying differing approaches, which leads to inefficient use of both operator and authority resources;

— the assessment and upgrading of existing facilities has been based on deterministic methods found in design standards, probabilistic / reliability - based methods or a combination of these;

— the level of detail delivered varies.

The purpose of this Technical Specification is to address the above concerns by providing a consistent approach to pipeline life extension assessment that can be applied by operators (or parties acting on their behalf) across the industry.

This Technical Specification is concerned with the proof of technical integrity of the pipeline system for the justification of extended operation. Integrity management is not covered in detail. However, the interface between a PIMS and the life extension process is considered because:

— a PIMS, where present, forms an integral part of the integrity assessment of the pipeline system;

— a PIMS of some form will be required for operation in extended life.

Factors affecting the future operability of the system but not the technical integrity, such as the loss of a control umbilical, will be flagged as requiring assessment but will not be addressed in full in this document.

Whilst this document is aimed primarily at the pipeline operators, it will also be of interest to other stakeholders such as:

— regulators approving the life extension application;

— members of the public affected by the life extension application, such as landowners and developers.

In light of this, an overview of the life extension process and the key principles involved is given in Clause 5. The remainder of the document is intended to provide detailed guidance to those performing the life extension assessments.

All guidance is provided for use in conjunction with sound engineering practice and judgement. This document is not intended for use as a design code.

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Pipeline transportation systems — Recommended practice for pipeline life extension

1 Scope

This Technical Specification gives guidance that should be followed, as a minimum, in order to assess the feasibility of extending the service life of a pipeline system, as defined in ISO 13623, beyond its specified design life. Pump stations, compressor stations, pressure-reduction stations and depots are not specifically addressed by this Technical Specification. This is illustrated in Figure 1.

This Technical Specification applies to rigid metallic pipelines. It is not applicable to the following:

— flexible pipelines;

— pipelines constructed from other materials such as glass reinforced plastics;

— umbilicals;

— topsides equipment;

— structures and structural components.

This Technical Specification is limited to life extension, which is an example of a change to the original design. Other changes, such as MAOP up-ratings are excluded.

NOTE The assessment methodology is applicable to other changes to the design at the discretion of the user.

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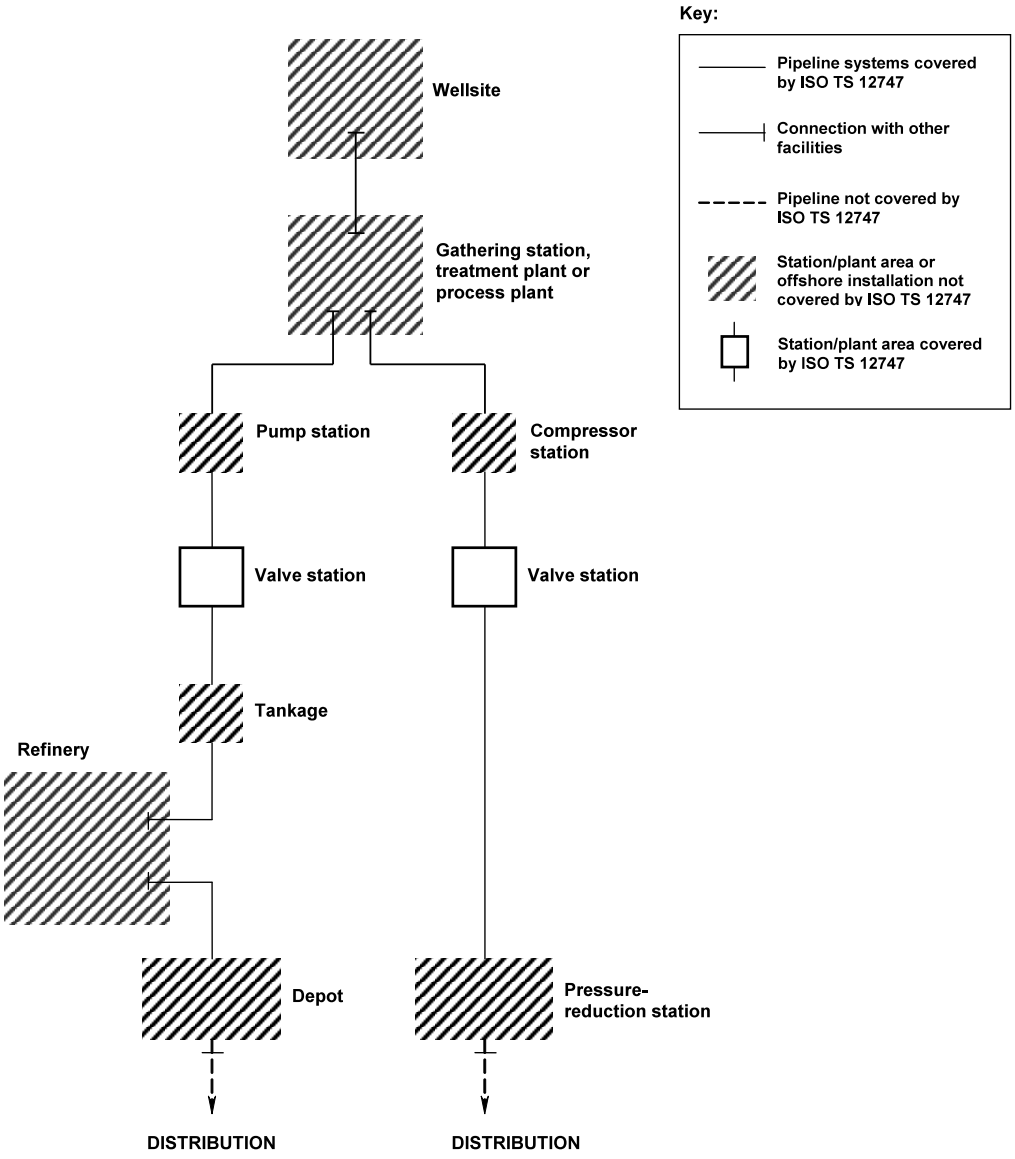

Figure 1 — Extent of pipeline systems covered by this Technical Specification

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2 Normative references

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

ISO 13623, *Petroleum and natural gas industries – Pipeline transportation systems*

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3 Terms and definitions

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

3.1
acceptance criteria
Specified indicators or measures employed in assessing the ability of a component, structure, or system to perform its intended function

3.2
anomaly
A discrepancy or deviation of an element of the pipeline system from the established rules and limits

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3.3
design life
Period for which the design basis is planned to remain valid

[ISO 13623]

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3.4
failure
Event in which a component or system does not perform according to its operational requirements

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3.5
flow assurance
Ensuring successful and economical flow of fluid through the pipeline system

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3.6
high integrity pressure protection system
Mechanical overpressure protection system that rapidly isolates the pipeline if there is a risk of the Maximum Allowable Operating Pressure (MAOP) being exceeded

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3.7
life extension
Additional period of time beyond the original design or service life (but within the assessed remnant life) for which permission to continue operating a pipeline system is granted by the regulatory bodies

NOTE Life extension is considered as a modification to the design basis.

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3.8
location class
Geographic area classified according to criteria based on population density and human activity

[ISO 13623]

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3.9
maximum allowable operating pressure
Maximum pressure at which the pipeline system, or parts thereof, is allowed to be operated

[ISO 13623]

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3.10
operation
The activities involved with running and maintaining the pipeline system in accordance with the design premise

3.11
operator
The party ultimately responsible for the operation and integrity of the pipeline system

3.12
pipeline integrity management system
Management system designed to ensure the safe operation of a pipeline system in accordance with the design intent, by control of the physical condition of a pipeline, the operating conditions within the system and any changes made to the system

3.13
pipeline
Those facilities through which fluids are conveyed, including pipe, pig traps, components and appurtenances, up to and including the isolating valves

[ISO 13623]

3.14
pipeline, offshore
Pipeline laid in maritime waters and estuaries seaward of the ordinary high water mark

[ISO 13623]

3.15
pipeline, onshore
Pipeline laid on or in land, including lines laid under inland water courses

[ISO 13623]

3.16
pipeline system
Pipelines, stations, supervisory control and data acquisition system (SCADA), safety systems, corrosion protection systems, and any other equipment, facility or building used in the transportation of fluids

[ISO 13623]

3.17
remnant life
Assessed period of time (irrespective of the defined design life) for which a pipeline system may be operated safely, based on time-dependent degradation mechanisms such as corrosion and fatigue

3.18
required life
Desired operational life of the pipeline, accounting for continued operation beyond the original pipeline design life

3.19
risk
The qualitative or quantitative likelihood of an event occurring, considered in conjunction with the consequence of the event

3.20
risk management
Policies, procedures and practices involved in the identification, assessment, control and mitigation of risks

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3.21
service life
The length of time over which the pipeline system is intended to operate

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3.22
technical integrity
Ability of the pipeline system to function in accordance with the design basis

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3.23
threat
Any activity or condition that may adversely affect the pipeline system if not adequately controlled

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3.24
topsides
Structures and equipment placed on a supporting structure (fixed or floating) to provide some or all of a platform's functions

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4 Symbols and Abbreviated terms

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CP	Cathodic Protection
ECA	Engineering Critical Assessment
ESD	Emergency Shut-Down
ESDV	Emergency Shut-Down Valve
HIPPS	High Integrity Pressure Protection System
ILI	In-Line Inspection
IP	Intelligent Pig
MAOP	Maximum Allowable Operating Pressure
PIMS	Pipeline Integrity Management System
QRA	Quantitative Risk Assessment
ROW	Right of Way
SCADA	Supervisory Control and Data Acquisition
VIV	Vortex-Induced Vibration

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BoD → → Basis of Design

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5 Life extension overview

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5.1 General

The design life of a pipeline is derived to prevent failure during operation due to time-dependent degradation mechanisms such as corrosion and fatigue. However, the expiry of the design life does not automatically mean that the pipeline system is not fit-for-purpose:

— corrosion rates determined during the design process might have been conservative and/or corrosion defects might have been repaired;

— the anticipated operational fatigue damage might have been overestimated.

Extended operation beyond the pipeline design life might be desirable when recoverable oil and gas remains, or where additional operational assets are tied (or are to be tied) into the pipeline system.

NOTE There are alternatives to pipeline life extension, such as installing a replacement pipeline. Therefore, a business case will be required to determine the most suitable option by comparing the cost of the mitigation necessary to achieve the desired life extension with the cost of a new pipeline.

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5.2 Assessment process

If the intention is to operate a pipeline system beyond its specified design life, a life extension assessment shall be performed. The aim of this assessment is to demonstrate that by extending the life of the pipeline system, the operator is not exposing society to unacceptable risk.

Figure 2 illustrates the pipeline system life extension assessment process. The shaded boxes highlight the distinct stages of the assessment and cross-references to the Clause of this Technical Specification dealing with a particular stage are provided.

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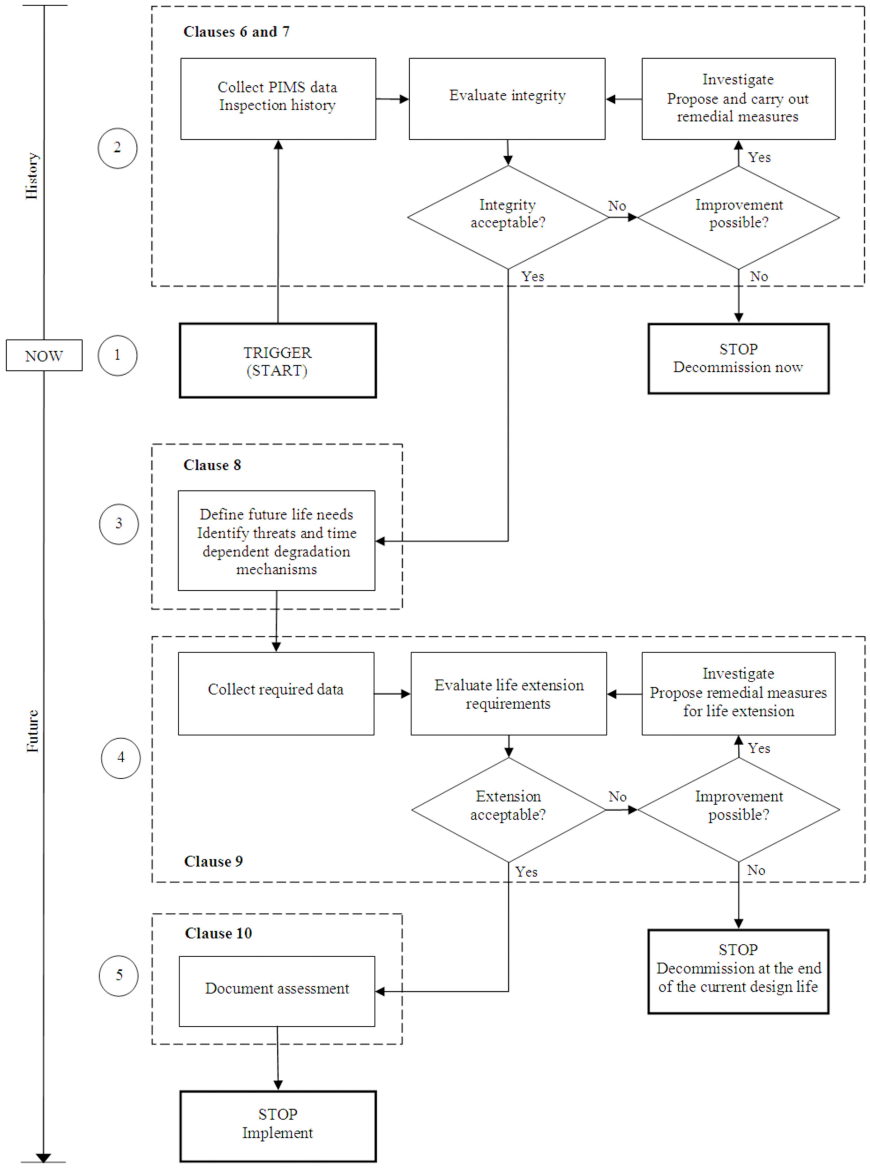

Figure 2 — Pipeline system life extension process

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The process begins with a requirement for pipeline extension (item 1) and an assessment of the current integrity of the pipeline system (item 2). The life extension needs should then be defined (item 3), prior to commencement of the life extension assessment (item 4).

The life extension assessment shall consider conditions found during the normal operational life that were not considered in the design. Examples are time dependent cracking mechanisms (e.g. SCC) and manufacturing flaws that could grow under the effect of cyclic loading. The requirements of the life extension assessment are discussed in more detail in 5.3.

Once an acceptable life extension has been determined, the assessment process shall be fully documented (item 5). If life extension is not possible (or if a replacement pipeline would be the most economical solution), the pipeline should be decommissioned at the end of the design life as originally planned.

5.3 Assessment requirements

The life extension process illustrated in Figure 2 involves an assessment of the current pipeline system integrity and an assessment to determine the suitability of the pipeline system for life extension.

The assessment of the current integrity (item 2) shall include, but not be limited to, the following:

— review of the pipeline system operational history;

— detailed assessment of the current technical integrity of the pipeline system.

The life extension assessment (item 4) shall include, but not be limited to, the following:

a) risk assessment for extended operation;

b) review of the pipeline system design, including a gap analysis to identify the additional requirements of the current design codes;

c) assessment of the remnant life of the system, including the following:

   — corrosion assessment, accounting for both accumulated and future corrosion in combination with a defect assessment;

   — fatigue assessment, accounting for both accumulated and future fatigue damage;

   — coating breakdown and CP system degradation assessment;

   — identification and assessment of any other time dependent degradation mechanism active in the pipeline.

d) revision or introduction of the PIMS for the extended operating period, including update of the anomaly limits;

e) the identification of any tenure issue (e.g. expiry of permit to occupy land) or statutory requirements (e.g. pipeline licence renewal), including a gap analysis to identify any additional regulatory requirements introduced during the pipeline design life;

f) review of the adequacy of the safety and operating systems;

g) review of the adequacy of the operating and maintenance, emergency response and safety and environmental procedures.

Additional studies shall be performed as required, in order to determine the need for remedial measures to mitigate the threats to the pipeline system anticipated during the extended operational period.

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5.4 Limitations on life extension

The allowable life extension is governed by the assessed remnant life of the pipeline system, as illustrated in Figure 3.

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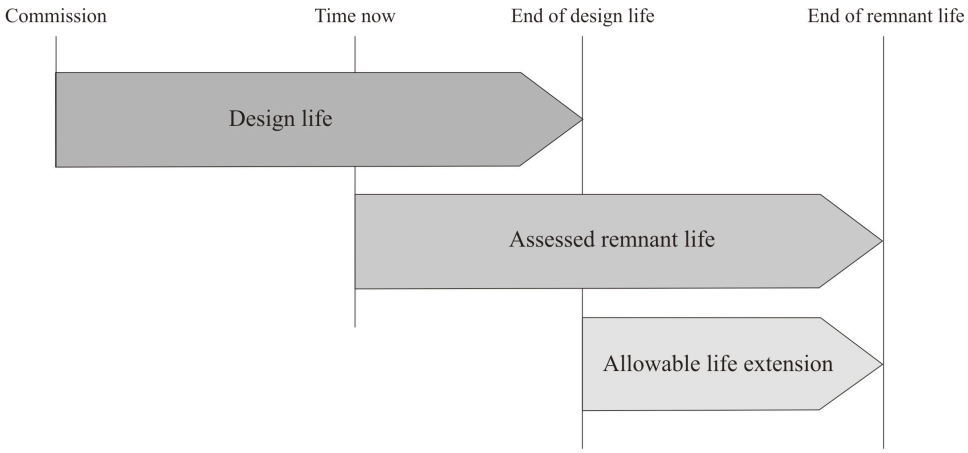

Figure 3 — Life extension and remnant life

If the required life of the pipeline system exceeds the remnant life, the remnant life assessment may be repeated considering the implementation of remedial measures such as:

— replacement of pipeline components;

— reassessment of anomaly limits and rectification of any anomalies;

— de-rating of the pipeline system.

Alternatively, it is possible for the life extension to be performed in stages. This is illustrated by the following examples.

EXAMPLE 1 A life extension of 20 years is required for a pipeline system, following the tie-in of a new asset, but the remnant life of the pipeline system is only 5 years due to excessive riser corrosion. In this case, an initial 5 year life extension could be made, followed by a further extension of 15 years upon replacement of the riser at the end of its remnant life.

EXAMPLE 2 A life extension of 20 years is required for a pipeline system, but due to the predicted corrosion rates, a reduction in MAOP will be required in 2 years. In a similar fashion to Example 1 above, an initial 2 year life extension could be made, with a further extension of 18 years subject to favourable results from an ILI run. If the ILI run confirmed the predicted corrosion rate, reduction in MAOP or rectification of the unacceptable defects would still be required after 2 years in order to achieve the required 20 year life extension.

5.5 Pipeline system availability

The guidance given in this Technical Specification is concerned with the proof of technical integrity of the pipeline system. However, the availability of the pipeline system during the life extension is also of critical importance. As such, a separate assessment of the integrity of the following should be carried out as part of the life extension process, as applicable:

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- pipeline system facilities, such as:
  - platform topsides;
  - pump stations;
  - compressor stations;
  - processing plants and terminals.
- instrumentation;
- control systems and equipment, such as SCADA;
- ancillary equipment.

6 Data compilation

6.1 General

Typical data required for a life extension assessment of a pipeline system is listed in 6.2. This does not constitute an exhaustive list, therefore additional data should be gathered as required. The use of accurate data is vital and the level of confidence in the data source shall be considered as part of the assessment.

When performing the life extension assessment, the degree of missing data shall be assessed and remedial actions, such as additional pipeline inspections or risk assessments, shall be identified where appropriate.

NOTE 1 When considering aging pipelines there is often data missing, especially if the operatorship has passed through several organisations.

NOTE 2 In specific instances, such as for CP surveys, the use of the most recent inspection results is appropriate.

6.2 Data

6.2.1 Original design

Original design data should include:

a) Original codes and standards, including edition number and date;

b) Design, fabrication and installation details;

c) Design basis;

d) Material specification and certification;

e) Analysis calculations and reports;

f) Hydrotest certificates;

g) Environmental Impact Assessments;

h) Risk assessments, including ECAs;

i) Pressure safety systems;

j) Inspection and test certification and reports;

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k) Documents relating to authorisation and permits to operate;

l) Regulatory requirements;

m) Land ownership details;

n) Surveys and route documentation, including location of other services and addition of third party services;

o) As-built route alignment maps, special crossing details, detailed pipework and instrumentation diagrams;

p) Deviations and non-conformities.

6.2.2 Operations data

Operations data should include:

a) Pipeline process philosophy and data sheets;

b) Operations philosophy;

c) Operating cycles, including pressure, temperature, flow and content analysis;

d) Operational pigging frequency and results, including liquid hold up and pig trash analysis;

e) Corrosion monitoring;

f) Erosion / sand monitoring;

g) Microbial monitoring;

h) Chemical management, including dosing regimes;

i) Process monitoring records, including gas composition;

j) Leak detection;

k) Safety systems e.g. HIPPS;

l) Control systems e.g SCADA;

m) Pressure systems;

n) Incident records;

o) Service conversions, including fluid content, dew point at inlet and outlet, liquid, hydrogen sulphide content, carbon dioxide content.

6.2.3 Maintenance and inspection data

Maintenance and inspection data should include:

a) Pipeline and material specifications;

b) Acoustic / video records;

c) Cathodic protection surveys;

d) Thermography;

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e) Ground penetrating radar;

f) Geographic information;

g) Settlement monitoring;

h) Crossing surveys;

i) Span monitoring;

j) Metocean data;

k) Pigging runs (operational and intelligent pigging);

l) Coating;

m) Anomaly records, including all pipeline system anomalies identified since construction;

n) Reports of all leaks and accidents;

o) Repairs and modifications, including operational changes e.g. change in operating temperature, pressure or flow rate;

p) Mechanical integrity of pig traps, valves and other components;

q) Inspection methods and techniques;

r) Corrosion records.

6.2.4 External data

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External data should include:

a) Regulations;

b) Design codes (national and international);

c) Pipeline registration documentation, permits and licences;

d) Building development and proximity distances changing the class of the pipeline system;

e) Geological faults;

f) Earthquakes, mudslides, subsidence.

7 Technical integrity of the pipeline system

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7.1 General

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The integrity of the pipeline system might have deteriorated since installation. The level of information available to characterise the deterioration experienced depends upon the monitoring and management systems implemented by the operator.

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NOTE Integrity management practice varies with different operators in different parts of the world. In some cases, an ongoing risk assessment process is adopted, whilst in other cases assessments are performed less frequently. Consequently the level of assessment required to justify life extension will vary.

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In order to determine whether the current technical integrity of the pipeline system is acceptable for life extension, an integrity assessment shall be performed based on the data and documentation detailed in Clause 6. There are numerous codes and standards that cover the assessment of pipeline integrity and these should be consulted for further guidance.

EXAMPLE API 1160, ASME B31.8S and DNV-RP-F116 address pipeline integrity assessment.

The technical integrity assessment shall evaluate:

a) the internal and external pipeline condition;

b) the effects of any repairs or modifications to the technical integrity of the pipeline system;

c) the status of the CP system;

d) the effect of any defects or anomalies on the technical integrity of the pipeline system and the need for remediation;

e) the status and condition of the safety systems;

f) the fitness-for-purpose of the pipeline system.

The integrity assessment should also consider the installation and commissioning of the pipeline system, paying particular attention to:

g) any new or non-standard construction methods that were used;

h) the presence of components (such as mitred bends) that are no longer accepted by current design codes;

i) any difficulties or unforeseen events that occurred (e.g. the presence of hydrotest water in the pipeline for longer than anticipated).

If sufficient data is not available to determine the technical integrity of the pipeline, further inspection, testing or analysis shall be carried out.

NOTE In practice this would involve ILI, hydrotest or direct assessment.

7.2 PIMS review

If the integrity of a pipeline system is governed by a PIMS, which is not always a requirement, the information provided should form the basis of the technical integrity assessment. The application of a PIMS is discussed in more detail in 9.4.

7.3 Remediation requirements

Following the assessment of the technical integrity, remedial actions might be required to ensure the fitness-for-purpose of the pipeline system for the remainder of the original design life. Typical remedial measures are discussed in 9.3.3.

NOTE In extreme cases, where remediation is not possible, the technical integrity assessment might result in decommissioning of the pipeline system prior to the end of the design life.

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8 Future threat identification

8.1 General

Threats to the pipeline system during the extended life period shall be identified and used as the basis of the risk assessment.

Common threats to a pipeline system are listed in 8.2 - 8.4. This list is not exhaustive and additional threat lists are presented in many design codes (e.g. API 1160, ASME B31.8S and DNV-RP-F116).

NOTE 1 Threats can be categorised as either time-dependent or event-based. It is the time-dependent threats that are of specific concern during life extension. Event-based threats typically pose no additional risk during extended life than during the design life.

NOTE 2 Threats experienced by specific pipeline systems differ greatly and, consequently, not all of the threats listed will be applicable.

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8.2 Generic threats

Generic threats common to both onshore and offshore pipeline systems that are applicable to life extension assessments include:

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— design, fabrication and installation issues;

— incorrect operation;

— internal and external corrosion;

— erosion;

— fatigue;

— overpressure;

— spans;

— global buckling;

— subsidence;

— deterioration of supporting structures and infrastructure;

— natural events such as earthquakes and volcanic eruptions;

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— munitions.

8.3 Threats specific to offshore pipeline systems

Additional threats to offshore pipeline systems include:

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— instability;

— collapse;

— scour;

— fishing interaction;

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— dropped objects;

— vessel impact;

— dragged anchors.

8.4 Threats specific to onshore pipeline systems

Additional threats to onshore pipeline systems include:

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— excavation damage;

— changes in land use surrounding the pipeline ROW;

— vehicle impact;

— vandalism or terrorism;

— unauthorised hot-tapping.

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9 Life extension assessment

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9.1 Risk assessment

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9.1.1 Process

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Risk assessment is the process of identifying threats to the integrity of the pipeline system, estimating the probability and consequence of failure before determining the acceptability of the risk. This is highlighted in Figure 4.

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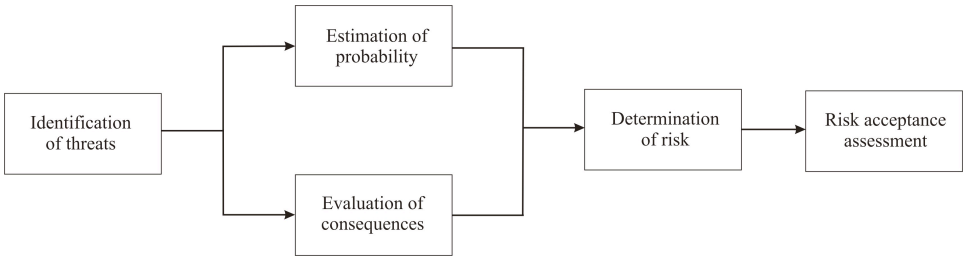

Figure 4 — Risk assessment process

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Risk assessment can be qualitative or quantitative. Qualitative risk assessment is subjective, whilst quantitative risk assessment provides a direct numerical measure of risk.

NOTE ISO 31000 provides further guidance on the risk assessment process.

9.1.2 Use of risk assessment in life extension

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The pipeline life extension assessment shall be based on a thorough understanding of the threats that the pipeline is subject to and the consequent risk to technical integrity. A risk assessment, considering the threats to the pipeline system during the extended operating period, shall therefore form a major part of the life extension assessment.

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The following approach shall be adopted:

a) perform an initial qualitative risk assessment to identify the major threats to the system;

b) perform a QRA of the major threats identified by the qualitative assessment.

The outcome of the risk assessment shall be an estimate of how long the pipeline system can be operated before the risk of failure exceeds an acceptable level.

9.1.3 Acceptability of risk

The acceptability of the risks identified by the risk assessment shall be assessed and remedial measures prescribed where necessary to reduce risks to acceptable levels. The assessment of risk acceptability for a pipeline life extension, however, is not a trivial process:

— operators, regulators and the general public have different views on acceptability of risk;

— the acceptability of risk changes with time and what was acceptable 20 years ago may not be now;

— the acceptability of risk changes with geographical location.

NOTE Further guidance on the acceptability of risk and target failure probabilities is given in ISO 16708.

9.1.4 Risk management

Risk management is the process of risk assessment, mitigation and periodic review as shown in Figure 5.

Figure 5 — Risk management process

The risk management process for the extended life period should be defined within the PIMS, as discussed in 9.4.1.

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9.2 Pipeline system design review

9.2.1 Design codes

9.2.1.1 Original design method

Design codes generally adopt either an allowable stress or limit-state approach to pipeline design. The design code used for the original pipeline design will have a significant effect on the life extension process.

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Pipelines designed to an allowable stress design code, such as PD 8010, are generally easier to assess than those designed using a limit-state design approach, such as that adopted in DNV-OS-F101. Allowable stress design codes are usually more conservative, resulting in a greater wall thickness to resist corrosion during operation. In addition, a pipeline designed using an allowable stress design code may still be considered as fit-for-purpose if the appropriate factors of safety are satisfied.

9.2.1.2 Updates to design codes

It is likely that the design codes to which the pipeline system was originally designed will have been updated during the operational period. This can result in non-conformance of the original design due to the following:

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— a change in the design methodology or safety factors;

— the prohibition of the use of components allowed in previous versions of the design codes, such as mitred bends.

A gap analysis shall be performed to identify any changes in design code requirements since installation and determine the compliance of the pipeline design with the current design codes. Where non-conformances are identified, risk assessment shall be used to determine the need for remedial actions.

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9.2.2 Changes to the design basis

The life extension assessment shall account for any changes to the original design basis. The consequences of any changes that have occurred during the design life or are anticipated as a result of life extension shall be addressed. Typical changes are discussed in 9.2.2.1, 9.2.2.2 and 9.2.2.3.

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9.2.2.1 Process conditions

Changes in process conditions can have a significant influence on pipeline corrosion rates and applied loads. These typically include:

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— changes in operating pressure, temperature and flow rate;

— changes in corrosion regime (e.g. sweet to sour);

— increased water cut;

— process shut downs;

— increased sand content;

— increased wax deposition.

9.2.2.2 Design loads

An assessment shall be performed to identify any changes to the original pipeline design loads. Such changes include:

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— an increase in environmental loading acting upon the pipeline system, including wave and current loading, wind loading and soil motion and deformation;

— an increase in interference loading (e.g. increase in fishing interaction loads on subsea pipelines due to the use of larger fishing gear);

— fatigue loading due to changes in process conditions (e.g. slugging);

— additional loading due to modifications and repairs.

The effect of any changes to the design loads on the acceptability of the pipeline design (in accordance with current codes and standards) shall be assessed. Remedial measures shall be identified as required.

9.2.2.3 Safety class

Increases in population density, changes in land use and changes in the pipeline corridor requirements over the design life can result in the enforcement of a more stringent location class (and hence safety class) in regions of the pipeline system. This can result in the non-conformance of the pipeline design with the requirements of the design codes.

In such cases, the additional risk to society shall be assessed and appropriate mitigation measures applied. This can result in the need to reduce the MAOP.

9.2.3 Additional data requirements

Any missing data required for the life extension assessment shall be identified. If the data cannot be obtained from other sources, remedial measures shall be considered. These may include:

— specification of additional inspection workscope to obtain the required information;

— use of advanced numerical modelling techniques;

— use of conservative assumptions in any assessments performed;

— use of a risk assessment to mitigate the consequences of the missing data.

9.3 Assessment of remnant life

The assessed remnant life of the pipeline system governs the allowable life extension, as shown in Figure 3. The assessment of remnant life shall account for all of the time-dependent threats identified in Clause 8. The most common of these threats are addressed in 9.3.1 and 9.3.2.

9.3.1 Corrosion assessment

Corrosion is usually the most significant internal degradation mechanism for pipelines, resulting in the loss of steel from the pipe wall. A corrosion assessment shall be carried out to determine the acceptability of any corrosion defects present for the remnant life of the pipeline system, including:

— assessment of external corrosion protection, including pipeline coatings and CP systems;

— determination of the corrosion rate, by corrosion modelling (deterministic or probabilistic) or comparison of defect dimensions between successive ILI runs;

— review of ILI data or direct assessment results as appropriate;

— acceptability assessment of the remaining pipeline wall thickness using current design codes;

— defect assessment;

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— assessment of the remnant life of the pipeline system based on the above corrosion rate.

NOTE Guidance on corrosion defect assessment is given in ASME B31G, BS 7910 and DNV RP F101.

The degree of uncertainty in the calculated corrosion rate (and therefore the remnant life) shall be determined, for example, through the calculation of upper and lower bounds as shown in Figure 6.

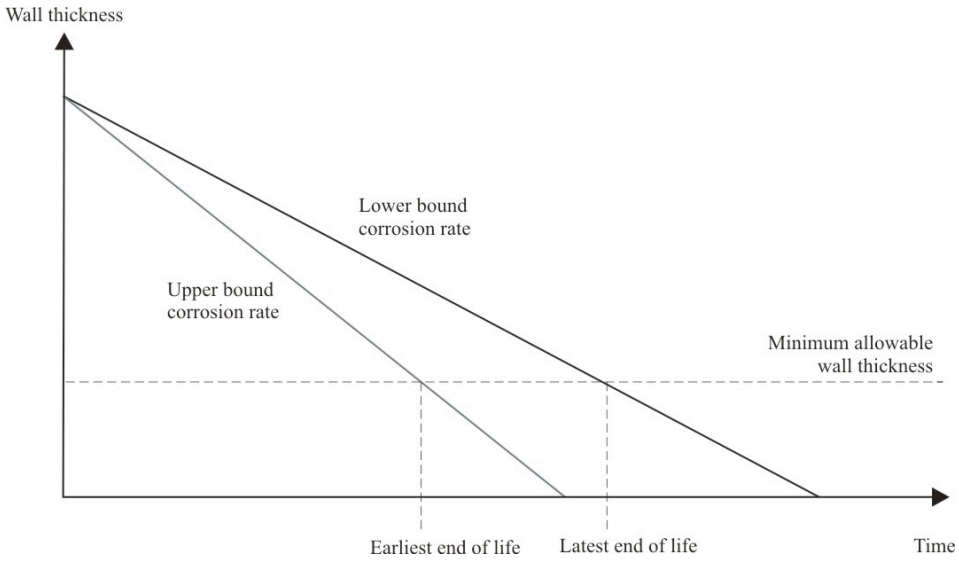

Figure 6 — Use of upper and lower bound corrosion rates

Further confidence in the results can be obtained from corrosion probe readings, inspections of pig traps and a review of the corrosion management system.

9.3.2 Fatigue and flaw assessment

A fatigue assessment shall be carried out accounting for both the accumulated and future fatigue damage to the pipeline system to demonstrate that the largest defect in the system will not grow through fatigue to failure during the extended life of the pipeline, including assessment of:

— design considerations and acceptance criteria;

— previous fatigue analyses;

— cyclic loading;

— spans;

— dents;

— defect assessment and ECA.

NOTE 1 Guidance on assessment of cyclic loading is given in DNV-RP-C203.

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NOTE 2 Guidance on the assessment of spanning subsea pipelines is given in DNV-RP-F105.

NOTE 3 Guidance on dent assessment is given in DNV-OS-F101, DNV-RP-C203 and OTH 561.

NOTE 4 Guidance on ECA is given in BS 7910.

If there is not sufficient data to perform a fatigue assessment, a QRA should be performed to determine whether the risk of fatigue failure is acceptable. Alternatively, a conservative fatigue analysis may be performed to account for the uncertainties in the data.

9.3.3 Remediation

If the remnant life of the pipeline system is found to be insufficient, the following remedial measures should be considered:

a) General:

   1) reduction in the desired life extension;

   2) modification of the flow regime;

   3) cut out and replacement of unacceptable sections or components.

b) Corrosion:

   1) introduction or modification of the corrosion inhibitor scheme;

   2) anode replacement or addition;

   3) reduction in the pipeline system MAOP, allowing greater metal loss;

   4) increase in the inspection frequencies to allow more accurate corrosion rates to be determined.

c) Fatigue:

   1) installation of supports or clamps;

   2) rockdumping or trenching of exposed sections of pipeline and spans;

   3) installation of VIV suppression devices.

9.4 Integrity management during extended life

9.4.1 PIMS

The integrity of the pipeline system should be managed during the extended operating period to ensure continued fitness-for-purpose. The PIMS and associated documents shall be modified as part of the life extension process to reflect any changes to the integrity requirements for the extended operating period.

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A PIMS typically covers the following:

— roles and responsibilities;

— operations and safety systems;

— technical integrity assessment;

— corrosion monitoring;

— fatigue and stress;

— modifications management;

— flow assurance;

— instrumentation and control;

— risk management.

NOTE Further guidance on the contents of a PIMS can be found in integrity management documents such as DNV-RP-F116.

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9.4.2 Inspection and monitoring

Inspection routines shall be reviewed as part of the life extension process and amended as appropriate. This is particularly important for risk-based inspection strategies, where the underlying risk assessment shall be reviewed in light of the findings of the life extension. This can result in more frequent inspections to mitigate an increased risk of failure in a deteriorating pipeline.

Monitoring and sampling activities shall also be reviewed to ensure that all of the data required to perform the regular integrity management assessments is collected.

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9.5 Regulatory requirements

The regulatory requirements for extended operation of a pipeline system differ worldwide and the requirements for the specific pipeline system, such as the renewal of permits and licenses and the update of the safety case, shall be identified.

A gap analysis shall be performed to identify modifications and additions to the regulatory requirements since the pipeline was installed. The associated risks of any such changes shall be assessed and mitigated.

9.6 Update of systems and procedures

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9.6.1 General

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To ensure the safe operation of the pipeline system during the extended life, whilst minimising the effects of a failure on the public and the environment, the control procedures and contingency plans shall be reviewed.

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9.6.2 Emergency response procedures

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The adequacy of the emergency response procedures over the extended life shall be assessed. These procedures shall be updated as necessary, accounting for any remedial work on the pipeline system.

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9.6.3 Operations and safety systems

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The fitness-for-purpose of the operating and safety systems shall be determined through inspection and testing. Any necessary maintenance to ensure the suitability of these systems for extended operation shall be performed.

10 Life extension report

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A detailed report, summarising the life extension assessment activities, shall be prepared. This report should include, as a minimum, the sections listed in Table 1.

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Table 1 — Contents of the life extension report

Section	Description
Executive summary	Overview of life extension process.
Introduction	Description of pipeline location, history and the purpose of the life extension requirement.
Conclusions	The findings of the life extension assessment, including: - remnant life and associated life extension period; - required legislative approvals; - deviations from original design basis and non-conformances; - deviations from current legislation and codes; - corrosion, fatigue and wall thickness assessment results; - any residual risks; - risk mitigation measures.
Recommendations	Recommendations for remedial measures or further inspection and assessment, necessary to justify life extension.
Licence, permit agreements and organisations	Licence holder, owner and operator structures and agreements. Past, present and future regulatory agreements should also be addressed.
Design and construction	Summary of pipeline system design and construction, including: - original design requirements, codes and specifications; - review of original design against current design codes; - description of any difficulties or unforeseen events prior to start-up; - construction methods (particularly new or non-standard methods).
Operation	Review of operational history and a summary of future operations.
Current integrity of the pipeline system	Review of the current integrity of the pipeline system, including: - condition of the pipelines, risers and tie-in spools; - condition and functionality of safety critical items such as ESDVs; - internal corrosion assessment, accounting for any chemical injection; - condition of coatings and CP systems; - assessment of the effects of any repairs or modifications; - fatigue assessment; - assessment of the effects of any changes in land use or settlement; - review of identified anomalies.
Life extension assessment	Description and findings of the life extension assessment covered by Clause 9 of this document.
Studies	Identification of any specific work or studies (past and future) that may have an impact on the pipeline and its life extension.
References	References to all documentation used during the compilation of the report.
Appendices	Useful information such as: - inspection and monitoring records used to assess pipeline integrity; - calculations performed during the life extension assessment.

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