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Pipeline systems

Part 4: Steel pipelines on land and
subsea pipelines – Code of practice
for integrity management

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Foreword

Publishing information

This part of PD 8010 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 July 2012. It was prepared by Subcommittee PSE/17/2, *Pipeline transportation systems*, under the authority of Technical Committee PSE/17, *Materials and equipment for petroleum*. A list of organizations represented on these committees can be obtained on request to their secretary.

Relationship with other publications

PD 8010-4 is a new part of the PD 8010 series. The series comprises:

- Part 1: *Steel pipelines on land*;
- Part 2: *Subsea pipelines*;
- Part 3: *Steel pipelines on land – Guide to the application of pipeline risk assessment to proposed developments in the vicinity of major accident hazard pipelines containing flammables – Supplement to PD 8010-1:2004*;
- Part 4: *Steel pipelines on land and subsea pipelines – Code of practice for integrity management*.

This part of PD 8010 should be read in conjunction with PD 8010-1 and PD 8010-2.

Information about this document

This part of PD 8010 was initially drafted using the Energy Institute document *Guidelines for the management of integrity of subsea facilities* [1] as a basis, with their kind permission. The EI document has been substantially changed to cover steel pipelines on land and subsea pipelines and to align with PD 8010-1 and PD 8010-2. The new PD 8010-4 is organized as follows:

- an extended introduction intended for senior executives;
- recommendations intended for use by integrity management practitioners;
- annexes giving additional information and guidance.

Use of this document

Integrity management is a complete process for a pipeline system, covering its life from design to abandonment. This part of PD 8010 gives guidance on integrity management through the design, construction, testing and operation phases of a pipeline system, as described in PD 8010-1 and PD 8010-2. It is intended to be used by integrity engineers, but it also provides guidance for design engineers, installation engineers, and people working in the supply chain. Managers at all levels within organizations are encouraged to read the Introduction, which explains the importance of integrity management of pipeline systems.

As a code of practice, this part of PD 8010 takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this part of PD 8010 is expected to be able to justify any course of action that deviates from its recommendations.

It has been assumed in the preparation of this Published Document that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions in this publication are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a Published Document cannot confer immunity from legal obligations.

0 Introduction

0.1 General

This part of PD 8010 provides all those with an involvement in pipeline systems – designers, equipment manufacturers, fabricators, constructors, installers, executive operators, site operators, control room operators, integrity and maintenance engineers, safety and associated pipeline personnel – with guidance on how to ensure that any pipeline system retains its integrity: i.e. that it continues to function as originally intended for the duration of the required operating life, which might be significantly longer than the original design life.

Subclauses **0.2** to **0.8** present the high level management policy and principles, and the framework under which a successful integrity management process can be achieved. These subclauses are recommended reading for all senior managers whose responsibilities are associated with the design, construction, testing or operation of pipeline systems.

Cross-references are given to the subclauses in the main text which deal with each issue in greater detail.

In any pipeline system, it is not sufficient solely to ensure that there are no leaks of hydrocarbons or other chemicals to the environment; the system needs to be able to transport fluids throughout its operating life without blockages, unacceptable reductions in flow rate, or de-rating required due to excessive corrosion or erosion. The management of reliability and maintainability in operations is closely related to integrity management.

Clauses **4** to **12** provide recommendations for executive operators, site operators, control room operators and contractors regarding:

- how to manage system integrity and reliability throughout the life of a pipeline system;
- the features that will encourage integrity and reliability, and support maintainability, throughout the pipeline system's operating life, from the design stage, including shut-down periods and into the decommissioning phase.

The recommendations can be applied to any pipeline system at any stage in its life (e.g. new facilities, or existing pipeline systems when the executive operator, site operator and control room operator will not have been involved at the design phase).

The aim of a pipeline integrity management system is to achieve safe operation and 100% availability and capacity at all times, except for planned shut-downs. Intervention due to a potential or actual integrity issue can result in significant repairs, or even full or partial shut-down. Subsea repairs can be particularly difficult as compared to pipelines on land.

It is much better to avoid the requirement for intervention, or to optimize such interventions that might be required, by paying attention to good design, high quality manufacture and careful installation, than to carry out unplanned interventions during the operating life. Good operation, inspection and maintenance are equally important in avoiding unplanned interventions.

0.2 Management policy

An integrity management policy is required for pipeline systems (see **4.1**).

0.3 Key principles

It is important that certain key principles are established, including:

- authorization at the highest level;
- adequate resources;
- definition of key roles and processes, including lines of communication with all third parties;
- regular review and auditing of processes;
- definition of necessary reports;
- interface management;
- definition of “failure”;
- investigation of incidents, including failures;
- consideration to through-life integrity management.

Further guidance is given in 4.2.

0.4 Outline of the integrity management process

The integrity management of a pipeline system includes the following activities:

- contributing to the design of the pipeline system;
- defining the pipeline system;
- subdividing the pipeline system into segments;
- defining the threats to the pipeline system;
- identifying the failure modes following from the threats;
- gathering failure likelihood data;
- identifying the consequences of each failure mode;
- carrying out a risk assessment;
- planning for mitigation;
- carrying out process and condition monitoring;
- carrying out inspection;
- carrying out repairs and modifications;
- managing information.

Further guidance is given in 4.3.

0.5 Management processes

The following specific processes are an important part of the overall integrity management process:

- operational procedures;
- spares philosophy;
- preparedness;
- review and audit;
- management of change;
- emergency response;

- incident investigation and learning;
- competence assurance.

Further guidance is given in 4.4.

0.6 Documentation

Every pipeline system will require documentation to be in place which will, as a minimum, address:

- risk mitigation;
- design, fabrication and installation;
- operations.

Further guidance is given in 5.2.

0.7 Key roles and responsibilities

It is important that the roles and responsibilities of all persons involved in pipeline integrity management are defined and, as a minimum, include the following roles:

- asset owner (3.1.2);
- responsible person (3.1.11);
- technical authorities (3.1.14);
- control room operator (3.1.8.1).
- executive operator (3.1.8.2);
- site operator (3.1.8.3).

Further guidance is given in 5.3.

0.8 Reporting

It is important to define the requirements for reporting, including but not limited to:

- reports to legislative authority;
- reports to senior management and third parties;
- reports of tests and inspections carried out;
- reports of non-conformities.

Further guidance is given in 5.4.

1 Scope

This part of PD 8010 gives recommendations and guidance on integrity management of steel pipelines on land and subsea pipelines, as defined in PD 8010-1 and PD 8010-2 respectively.

2 Normative references

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

PD 8010-1, *Code of practice for pipelines – Part 1: Steel pipelines on land*

PD 8010-2, *Code of practice for pipelines – Part 2: Subsea pipelines*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this part of PD 8010, the terms and definitions given in PD 8010-1, PD 8010-2 and the following apply.

3.1.1 anomaly limit

value of a parameter of a potential failure mode above or below which the component is no longer considered fit for purpose

3.1.2 asset owner

individual who is responsible to the senior management for the performance of an asset

3.1.3 failure mode

manner in which a component or system might fail

NOTE Typical failure modes for pipelines include leak and rupture.

3.1.4 header

<of manifold> principal component of pipework that is normally used for gathering production

3.1.5 inline inspection tool

device or vehicle that uses a non-destructive testing technique to inspect a pipeline from the inside

NOTE Most inline inspection tools use either MFL or UT measurements to measure wall thickness, coating defects and identify other inline pipeline defects.

3.1.6 integrity management

set of processes that ensures incident-free transportation of fluids through a pipeline system

3.1.7 J-tube

rigid tube on a platform through which a riser (rigid or flexible) is pulled

3.1.8 operators

3.1.8.1 control room operator

individual who manages and controls a pipeline system

3.1.8.2 executive operator

company or organization responsible for the operation of pipeline systems

NOTE In the industry, this is usually referred to as an "Operator", with an upper case "O".

3.1.8.3 site operator

company or organization responsible for carrying out the instructions of the executive operator

NOTE In the industry, this is usually referred to as an "operator", with a lower case "o".

3.1.9 produced water

water native to a reservoir and produced with hydrocarbons

3.1.10 quill

component of chemical injection that ensures proper dispersal of the chemical into the flow

3.1.11 responsible person

person who is knowledgeable about the operation of the pipeline system and who takes responsibility for its integrity

3.1.12 risk assessment

process of identifying threats to the integrity of a pipeline, estimating the likelihood and consequence of failure to determine risk, and evaluating the calculated risks to determine their significance

3.1.13 safe operating limit

value of an operating parameter beyond which the system should not be operated

3.1.14 tree

system for isolating and controlling the flow to and from a well

3.1.15 umbilical core

tube or tubes for the conveyance of hydraulic fluid or chemical

3.1.16 water cut

percentage of produced water (3.1.9) in the production stream

3.1.17 water injection

process of injecting water into a reservoir to maintain reservoir pressure and/or sweep out oil

3.1.18 wax

long chain paraffins (alkanes), generally with 20 or more carbon atoms

NOTE Pure waxes are white odourless solids with melting points between 45 °C and 65 °C.

3.2 Abbreviations

For the purposes of this part of PD 8010, the following abbreviations apply.

CDT	current drain test
CIPS	close interval potential survey
CIS	chemical injection system
ESD	emergency shut-down
ESDV	emergency shut-down valve

HAZID	hazard identification study
HAZOP	hazard and operability study
HPU	hydraulic power unit
IPPS	instrumented pressure protection system
IRCD	injection rate control device
LRU	long range ultrasonics
MEG	monoethylene glycol
MFL	magnetic flux leakage
MIC	microbially-induced corrosion
MoC	management of change
NDT	non-destructive testing
ROV	remotely operated vehicle
SCADA	supervisory control and data acquisition system
SIT	silicon intensifier target
SMART	specific, measurable, achievable, relevant, time-based
SRB	sulphate reducing bacteria
SSIV	subsea isolation valve
SSS	side-scan sonar
TEG	triethylene glycol
UT	ultrasonic testing (inspection and measurement)
UTM	umbilical termination module

4 General recommendations

COMMENTARY ON CLAUSE 4

The term “integrity management” encompasses all the activities required to ensure that a pipeline system delivers the design requirements throughout the required operating life. It also includes all activities required prior to commissioning (e.g. design, procurement, fabrication, installation) to ensure that the system is optimized for achieving integrity throughout its life, and all activities required to make decommissioning or out-of-service planning as straightforward as possible.

4.1 Management policy

The integrity management policy should define the basis upon which the integrity management process for a pipeline system is established.

NOTE A set of typical policy requirements is given in Annex A.

4.2 Key principles

The key principles for a successful and effective integrity management process are listed below.

- a) The policy should be authorized at the highest level in the organization and should be promulgated to every person who has an involvement with pipeline operations, in every asset, as a fundamental aim of the organization.

- b) The organization should provide adequate resources, in terms of both equipment (including software) and suitably qualified, trained and experienced personnel, for the achievement of the policy.
- c) The organization should define key integrity management roles, lines of communication and responsibilities.
- d) The organization should require the definition of the integrity management process by the designated responsible individual(s). The process should be clearly defined, including performance indicators, and should be audited regularly. Some performance indicators should measure the performance of senior management.
- e) The organization should ensure that the processes are reviewed and audited regularly (e.g. annually), and updated as required.
- f) The reports required by senior management, and by the relevant legislative authority, should be clearly defined.
- g) Particular attention should be paid to managing interfaces in the system, e.g. between technical groups, between the organization and third parties, and between project phase and operations.
- h) The term “failure” should be clearly defined in the context of the organization. Some might view failure as limited to loss of containment of hazardous fluids to the environment, possibly with safety implications, whereas others might view any condition that constrains maximum production as a failure.
- i) All incidents (including failures) should be fully investigated and the outcomes promulgated to ensure that lessons are learned and good practice updated.
- j) It should be emphasized that integrity management commences during the design phase (with definition of maintainability and integrity management-friendly design), and continues throughout the life cycle into the decommissioning phase.

4.3 Outline of the integrity management process

COMMENTARY ON 4.3

The integrity management of a pipeline system involves the activities outlined in 4.3.1 to 4.3.13. It is important to recognize that the outputs of the early activities (e.g. defining the pipeline system, system subdivision, defining the threats, etc.) are not fixed: rather, they are all part of a live system that will need to be adjusted in the light of operating experience and changes.

4.3.1 Contribute to the design of the pipeline system

Personnel who are knowledgeable in the operation of pipeline systems should contribute to the design and procurement process, in order to achieve the policy objectives. Executive operators, site operators, control room operators and third party operators should understand, and agree with, the assumptions made, and should define potential mitigations if any of these assumptions prove in service to be incorrect.

4.3.2 Define the pipeline system

The limits of the pipeline system for which the integrity management activities apply should be clearly defined and documented.

4.3.3 Subdivide the pipeline system into segments

The risks are not uniform throughout a pipeline system, partly due to geography and geometry, partly because of changes in internal conditions (e.g. fluids hotter nearer the production well or after a pump/compressor station), and partly because unrelated, threatening activities might be localized. The pipeline system should therefore be divided into segments, selected to seek uniformity of risks, or risk management. Components of the system (e.g. SCADA, leak detection or CIS) may also constitute segments. Care should be exercised not to overly segment the pipeline, as each segment requires the completion of the risk assessment process.

NOTE See Annex B for further guidance on CIS.

4.3.4 Define the threats to the pipeline system

The threats constitute the generic causes that can lead to failure of components within different segments of different pipeline systems, based upon world-wide operating experience. The possible threats should be addressed for each defined segment of the pipeline in question, taking full account of their specific characteristics. A threat list should be created (see 7.2).

4.3.5 Identify the failure modes following from the threats

The threat list (see 4.3.4) should be used as the basis for defining the failure modes that apply to each component of each segment.

The initial identification of failure modes should be carried out during the design phase, at the same time as the initial risk assessment (see 4.3.8).

4.3.6 Gather failure likelihood data

Data should be obtained on the probabilities of different threats and failure modes in different locations and conditions. Information on the effectiveness of mitigation should also be obtained as it becomes available.

4.3.7 Identify consequence of failure modes

The consequence of failure associated with each failure mode should be assessed for each segment (see 7.2.6).

4.3.8 Carry out a risk assessment

A risk assessment should be carried out (see 7.2), working through each component in each segment, listing every applicable failure mode, and assigning probability and consequence values.

NOTE Risk is the product of probability and consequence. Probability can be assigned quantitatively or qualitatively to the failure mode in question. Consequence includes safety, environmental damage, need for containment and repair, deferral of production, and impact on reputation.

The risk assessment should be carried out for the base case, without mitigation, and then for the mitigated case. The reason for this is that the mitigation activities (i.e. activities to be carried out by, or on behalf of, the integrity management personnel during operations) effectively define the integrity management process and, if these are not carried out, the risk reverts to the unmitigated value.

It is important that senior management recognize the implications of not carrying out the mitigation activities (i.e. heightened risk of failure), and provide adequate resources and support to the integrity management process.

4.3.9 Introduce mitigation

The mitigation activities should be identified during the risk assessment, which should also facilitate prioritization of tasks, including:

- a) inspection;
- b) surveillance;
- c) monitoring;
- d) sampling;
- e) testing;
- f) maintenance.

NOTE Further guidance is given in Annex C.

4.3.10 Carry out process and condition monitoring

Monitoring, sampling and testing should be carried out in accordance with the mitigation measures (see 4.3.9). The condition of equipment should be ascertained, and the need for maintenance should be assessed.

Much of the data will be obtained through process monitoring. Data acquisition is therefore not risk-based, but the schedule for review of relevant data by the integrity management team should be.

4.3.11 Carry out inspection and surveillance

Inspections should be carried out to validate that the pipeline segment is operating within the required parameters, and that the mitigation measures (see 4.3.9) are effective. This may be achieved by the use of internal inspections using inline inspection tools, and external inspections incorporating visual, sonar and above-ground survey techniques.

NOTE Subsea inspection can be carried out by divers, but they are limited by water depth and local metoceanographical conditions.

4.3.12 Carry out repairs and modifications

Repairs and/or modifications should be carried out as required to address any anomalies identified during inspection.

4.3.13 Manage information

The acquisition and management of data is an essential part of the integrity management process.

Data trending should be used to reveal degradation and to allow the assessment of the point at which a component will cease to be fit for purpose (e.g. wall thickness reaches an unacceptable limit).

Data, including calculations, analyses, reports, etc., should be stored centrally, and be accessible (with the necessary security) to a variety of users. Where possible, data should be integrated with respect to length/position/chainage along the pipeline, in order to identify location-specific issues.

4.4 Management processes

4.4.1 Operational procedures

NOTE See also 5.2.4.

Operational procedures should be clearly established and laid out for integrity to be successfully managed. Day-to-day operations are always subject to unexpected occurrences, and the risk of these should be assessed and plans for the required rectification put in place.

4.4.2 Spares philosophy

NOTE See also 11.2.

The risk assessment leads to the priority list of failure modes. If the most likely failures can be prevented or repaired by replacement of components, then the system can be brought on line most quickly if spares are stocked. However, some spares can lose calibration, or degrade, while in storage. The spares philosophy should take account of both the positive and negative aspects of stocking spares.

Where spares are held, maintaining the integrity of those spares, and the management of obsolescence, should be part of the integrity management process.

4.4.3 Preparedness

NOTE 1 See also 11.3.

The risk assessment should include the creation of a priority list of threats and failure modes. The response required for some failures might involve major shut-downs and complex interventions (e.g. serious internal corrosion of a pipeline). Contingency plans should be developed for the threats and failure modes higher on the priority list that fall into this category. Contingency planning should include:

- how to blow down the system;
- how to calibrate or measure the defect;
- understanding examination and testing protocols (e.g. inline inspection);
- suppliers of intervention equipment (e.g. hot tap spreads, welding habitats);
- primary intervention contractors;
- preparing procedures for the activities that will be required.

NOTE 2 The integrity management process defines what failures might occur.

4.4.4 Review and audit

NOTE See also Clause 12.

Senior management should expect the responsible person for the pipeline system to regularly review the integrity management process. They should also require that the process is audited by an independent body at intervals.

Senior management have responsibilities in relation to integrity management, and should anticipate that some performance indicators will relate to their own performance (e.g. provision of adequate resources).