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SLOVENSKI STANDARD
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Naftna in plinska industrija, vključno z nizkoogljično energijo - Transportni cevovodni sistemi - Metode na podlagi mejnih stanj zanesljivosti (ISO/DIS 16708:2026)

Oil and gas industries including lower carbon energy - Pipeline transportation systems - Reliability-based limit state methods (ISO/DIS 16708:2026)

Erdöl- und Erdgasindustrie - Rohrleitungstransportsysteme - Zuverlässigkeitsanalysen (ISO/DIS 16708:2026)

Industries du pétrole et du gaz, y compris les énergies à faible teneur en carbone - Systèmes de transport par conduites - Méthodes aux états limites basées sur la fiabilité (ISO/DIS 16708:2026)

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Oil and gas industries including lower carbon energy — Pipeline transportation systems — Reliability-based limit state methods

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Contents

Page

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).

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

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

This second edition cancels and replaces the first edition (ISO 16708:2006), which has been technically revised.

The main changes are as follows:

— Adaption to latest research

— Consideration of updated damage data bases

— Consideration of updated calculation methods

— Consideration of conversion of transported media

— Alignment with other standards

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

The International Standard ISO 13623 allows the use of innovative techniques and procedures providing the requirements of ISO 13623 are satisfied but still allowing to change the applied safety margins provided the target safety levels given in this standard are fulfilled.

Reliability limit states methods have been developed and considered as included in those allowed techniques and procedures.

Pipeline integrity management during design and operation are performed by the following two limit state approaches:

a deterministic approach, with the use of safety or usage factors applied to characteristic loads and resistances; and a probabilistic approach, based on structural reliability analysis applied to the relevant limit states, e.g. reliability-based limit state methods.

Both approaches satisfy the safety requirements; implicitly by the deterministic approach (via earlier-calibrated safety factors) and explicitly by the probabilistic approach (a direct check on the actual safety level) as illustrated in Figure 1.

Significant differences exist among member countries in the areas of public safety and protection of the environment. Within the safety framework of this International Standard, such differences are allowed for, and individual member countries can apply their national requirements for public safety and the protection of the environment to the use of this International Standard.

Oil and gas industries including lower carbon energy — Pipeline transportation systems — Reliability-based limit state methods

1 Scope

This International Standard specifies the functional requirements and principles for design, operation and requalification of pipelines in the petroleum and natural gas industries using reliability-based limit state methods as permitted by ISO 13623. Reliability-based limit state methods provide a systematic way to predict pipeline safety in design and operation.

This International Standard supplements ISO 13623 and can be used in cases where ISO 13623 does not provide specific guidance and where limit states methods can be applied, such as, but not limited to,

— qualification of new concepts, e.g. when new technology is applied or for design scenarios where industry experience is limited,

— re-qualification of the pipeline due to a changed design basis, such as service-life extension or change of the transported fluid, which can include reduced or increased uncertainties due to improved integrity monitoring and operational experience or limited information on pipeline properties relevant to the new service

— collapse under external pressure in deep water,

— extreme loads, such as seismic loads (e.g. at a fault crossing), ice loads (e.g. by impact from ice keels),

— situations where strain-based criteria can be appropriate.

This document applies to rigid metallic pipelines on-land and offshore used in oil and gas industries including lower carbon energy.

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 3183, *Petroleum and natural gas industries — Steel pipe for pipeline transportation systems*

ISO 12747, *Oil and gas industries including lower carbon energy — Pipeline transportation systems — Requirements and guidance for pipeline life extension assessment*

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

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

ISO 17776, *Petroleum and natural gas industries — Offshore production installations — Major accident hazard management during the design of new installations*

ISO 19345, *Petroleum and natural gas industry — Pipeline transportation systems — Pipeline integrity management specification*

EN 1991-1, *Eurocode 1, Basis of Design and Actions on Structures, Part 1, Basis of design*

3 Terms and definitions

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

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

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

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

3.1
basic variable
text of the definition load or resistance variable entering the limit state function including the variable accounting for model uncertainty in the limit state function itself

3.2
characteristic load
nominal value of a load to be used in determination of load effects

Note 1 to entry: Characteristic load is normally based upon a defined fractile in the upper end of the distribution function of the load..

3.3
characteristic resistance
nominal value of a strength parameter to be used in determination of capacities

Note 1 to entry: Characteristic resistance is normally based on a defined fractile in the lower end of the distribution function of the resistance..

3.4
characteristic value
nominal value to characterize the magnitude of a stochastic variable

Note 1 to entry: Characteristic value is normally defined as a fractile of the probability distribution of the variable.

3.5
commissioning
activities associated with the initial filling of a pipeline system with the fluid to be transported

[SOURCE: ISO 13623]

3.6
construction
phase comprising installation, pressure testing and commissioning

3.7
design life
period for which the design basis is planned to remain valid

[SOURCE: ISO 13623]

3.8
design point
most probable outcome of the basic variables when failure occurs

Note 1 to entry: The design point is the point on the limit-state surface with the highest probability density.

3.9
design value
value to be used in the deterministic design procedure, i.e., characteristic value multiplied by the safety factor

3.10
failure
loss of ability of a component or a system to perform its required function

3.11
fluid category
categorization of the transported fluid according to hazard potential

3.12
importance factor
dimensionless number between zero and one describing the contribution of a random variable to the overall uncertainty

3.13
inspection
processes for determining the status of items of the pipeline system or installation and comparing it with the applicable requirements

EXAMPLE Inspection can be by measuring, examination, testing, gauging or other methods.

3.14
limit state
state beyond which the pipeline no longer satisfies the design requirements

Note 1 to entry: Categories of limit states for pipelines include serviceability limit state (SLS) and ultimate limit state (ULS). Ultimate limit states include fatigue and accidental limit states as well.

3.15
limit-state design
structural design where specific limit states relevant for the actual case are explicitly addressed

Note 1 to entry: A limit-state design check can be made both using the deterministic approach or using the probabilistic approach where uncertainties are modelled.

3.16
limit state function
function of the basic variables, which has negative values when the structure fails and positive values when the structure is safe

3.17
load
any action causing deformation, displacement, motion, etc. of the pipeline

3.18
load combination
set of loads acting simultaneously

3.19
load effect
effect of a single load or load combination on the pipeline

EXAMPLE Load effects include stress, strain, deformation, displacement, bending moment, axial force.

3.20
location class
geographic area classified according to criteria based on population density and human activity

[SOURCE: ISO 13623]

3.21
maintenance
all activities designed to retain the pipeline system in a state in which it can perform its required functions

Note 1 to entry: These activities include inspections, surveys, testing, servicing, replacement, remedial works and repairs.

[SOURCE: ISO 13623]

3.22
maximum allowable incidental pressure
MAIP
maximum allowable internal pressure due to incidental operation of the pipeline or pipeline section

3.23
maximum allowable operating pressure
MAOP
maximum allowable pressure at which a pipeline system, or parts thereof, is allowed to be operated in compliance with this document

Note 1 to entry: The MAOP is established by the maximum pressure achieved during testing

[SOURCE: ISO 13623]

3.24
mean value
first order statistical moment of the probability distribution function of the considered variable

3.25
mill test pressure
test pressure applied to pipe joints and pipe components upon completion of manufacture and fabrication at the mill

3.26
model uncertainty
uncertainty in the predictions of a selected calculation model that remains when the exact values of all input parameters are known

EXAMPLE Load model, strength model, function model for the pipeline.

3.27
nominal wall thickness
specified wall thickness of a pipe, which is equal to the minimum design wall thickness plus the negative manufacturing tolerance and the corrosion allowance

3.28
normal operation
conditions that arise from the intended use and application of the pipeline, including associated condition and integrity monitoring, maintenance and repair

Note 1 to entry: Normal operations include steady flow conditions over the full range of design flow rates, as well as possible packing and shut-in conditions.

3.29
ovality
deviation of the pipeline perimeter from a circle, having the form of an elliptical cross-section

3.30
pipeline
those components of a pipeline system connected together to convey fluids between stations and/or plants, including pipe, pig traps, components, appurtenances, spools, risers, isolation valves, and sectionalizing valves

[SOURCE: ISO 13623]

3.31
offshore pipeline
pipeline laid in maritime waters and estuaries seaward of the ordinary high water mark

[SOURCE: ISO 13623]

3.32
onshore pipeline
on-land pipeline
pipeline laid on or in land, including lines laid under inland waterways

Note 1 to entry: pipelines laid in large inland water bodies such as lakes can be designed, constructed and operated in the same way as offshore pipelines.

[SOURCE: ISO 13623]

3.33
reliability
ability of a component or a system to perform its required function without failure during a specified time interval

Note 1 to entry: Reliability equals 1 minus the failure rate, P_f.

3.34
risk
combination of the probability of an event and the consequences of the event

Note 1 to entry: Individual risk is related to the risk of a single person injury/death and societal risk is the risk of human safety in the entire society affected by the pipeline.

[SOURCE: ISO 17776]

3.35
safety class
concept to classify the criticality of pipelines in the event of failure

3.36
safety factor
γ
factor by which the characteristic value of a variable is multiplied to give the design value

3.37
specified minimum tensile strength
SMTS
minimum ultimate tensile strength required by the specification or standard under which the material is purchased

[SOURCE: ISO 13623]

3.38
specified minimum yield strength
SMYS
minimum yield strength required by the specification or standard under which the material is purchased

[SOURCE: ISO 13623]

3.39
system effect
System effects are present when potential structural failure occurs in connection with the weakest pipe joint.

[SOURCE: DNV ST F101[1] modified “pipe section” with “pipe joint”]

3.40
system reliability
reliability of a system of more than one element, or the reliability of an element which has more than one relevant failure mode

3.41
target safety level
maximum acceptable failure probability level for a particular pipeline and limit state condition

4 Symbols and abbreviated terms

4.1 Symbols

C_f	consequences of a given failure
$g(x)$	limit state function
P_f	probability of a failure, i.e. the actual failure rate calculated
$P_{f,target}$	target safety level, equal to the target probability of failure
R	resistance or the capability of a structure or part of a structure to resist load effects
R_C	characteristic value of component resistance, based on characteristic values of material properties
S	load effect on a structure or part of a structure
S_C	characteristic load effect
$S_{C,E}$	environmental load effects
$S_{C,F}$	functional load effects
γ	safety factor
γ_{i}	partial load effect factors
γ_R	resistance factor
μ	mean
σ	standard deviation
σ_y	yield strength
σ_u	ultimate tensile strength
γ_{Ri}	resistance factors

4.2 Abbreviated terms

ALS	accidental limit state
CTOD	crack tip opening displacement
CoV	coefficient of variation
FLS	fatigue limit state
FORM	First-order reliability method
LRFD	load and resistance factor design
MAIP	maximum allowable incidental pressure
MAOP	maximum allowable operating pressure
QRA	quantitative risk analysis
SLS	serviceability limit state
SMTS	specified minimum tensile strength
SMYS	specified minimum yield strength
SORM	Second-order reliability method
SRA	structural reliability analysis
ULS	ultimate limit state

5 Principles for design and operation

Pipeline design and operational principles can be implemented using different methods with varying levels of detail as indicated in Figure 1. In order of decreasing level of detail, these methods are quantitative risk analysis (QRA) and structural-reliability analysis (SRA), both of which are probabilistic, and the deterministic limit-state design methods [partial safety-factor design and load and resistance-factor design (LRFD)], which are collectively termed LRFD in this document.

The LRFD formats apply partial safety factors to the characteristic load and resistance properties, representing more traditional design for pipelines. This is the format applied in ISO 13623 by the use of the hoop stress design factor and the equivalent stress design factor, i.e. one partial factor only. This approach is classified as deterministic, as no quantitative information about the safety margin is given. The partial safety factors in the LRFD format have to be calibrated by the use of reliability-based methods prior to the publication to satisfy its design requirements and provide a satisfactory safety margin. The routine use of the LRFD formats do not, therefore, require the partial safety factors to be determined. In LRFD approaches (see left side of Figure 1), the load and resistance are defined by their characteristic values and partial safety factors are applied separately (as required) to the characteristic values of load, resistance and material properties.

Application of the probabilistic approach (SRA and QRA) involves the steps on the right hand side of Figure 1. The limit-state definition is generally the same as for the LRFD. In this approach, load effects and resistance are represented by probability functions, given in terms of distribution type, mean value and standard deviation. This approach is classified as probabilistic, as quantitative information about the safety margin in terms of reliability or the complementary failure probability is given to be compared with the target failure rate to be defined in accordance with this standard. The most comprehensive probabilistic method is QRA, as it takes into consideration the consequences of failure.

The format and requirements for the reliability-based limit state method are described in Clause 6.