

DEP SPECIFICATION

**PIPELINE ENGINEERING – RELIABILITY-BASED LIMIT
STATES METHODS
(AMENDMENTS/SUPPLEMENTS TO ISO 16708)**

DEP 31.40.10.18-Gen.

February 2017

DESIGN AND ENGINEERING PRACTICE



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1. PART I INTRODUCTION

1.1 SCOPE

This DEP applies when the option in ISO 13623:2009 Clause 6.1 to apply “reliability-based limit states design methods” is invoked. This DEP specifies requirements and gives recommendations for the application of such methods.

This DEP is based on ISO 16708:2006. Part III of this DEP amends, supplements and deletes various clauses of ISO 16708:2006. For ease of reference, the clause numbering of ISO 16708 has been used throughout Part II of this DEP.

All clauses of ISO 16708:2006 not modified by this DEP remain valid as written.

It is not the intent of this DEP to determine when limit states design methods may be used, but only provide requirements that apply if such methods are used.

The objectives of this DEP are to establish minimum requirements for due diligence in performing (reliability-based) limit states design, and to introduce standardized terminology to facilitate communications and reviews of criteria used, but it does not include any required specific quantitative criteria to be used in (reliability-based) limit states design.

This DEP is a revision of the same number dated February 2016; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use for pipelines related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

NOTE: In ISO 16708, the term **Owner** is used. In this DEP, the term **Owner** shall be understood to mean the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

In addition to the following definitions, those from ISO 16708:2006 as amended in (Part III-3) also apply.

Term	Definition
Balanced Stochastic Range	Represents a stochastic range for which the probability that the outcome falls outside the range on upper and lower sides are equal.
Complementary Distribution Function	The complementary distribution function $G(x)$ for a real-valued random variable X gives the probability that the outcome exceeds a specified value of X , which is the argument for which the function is evaluated.
Cumulative Distribution Function	The cumulative distribution function $F(x)$ for a real-valued random variable X gives the probability that the outcome is less a specified value of X , which is the argument for which the function is evaluated.
Design Methodology Document	Document that specifies the design methods described in (Part III-5), to be used for which limit state, in such a way that all relevant limit states and uncertainties are covered. It includes criteria for each case, with tolerable failure probabilities where applicable, either directly or by reference to one or more Design Specification Documents.

Term	Definition
Design Specification	Document containing a detailed specification of the criteria to be applied in the design for specific limit state(s) and loading conditions. This may be based on probabilistic or deterministic criteria. It contains a position on relevant engineering judgements, and/or assumptions to be made, so that any two engineers using the design specification to assess a design against specific limit states would arrive at the same conclusion regarding the fitness for purpose of the design, except to the extent that defining the inputs to the design checks requires engineering judgement. (E.g., if the 100-year wave height at a specific location is one of the inputs to the design check, the two engineers may differ on how they arrive at this parameter from the available information, hindcast simulations.)
Effective Value	The effective value of an input parameter to the limit states function is the value for which the selected limit states function yields the correct prediction in regard to specified uncertainties.
Equivalent Standard Normal Value	For a particular value x of a random variable X, the equivalent standard normal value is a value z of a standard normally distributed random variable Z that has the same probability of being exceeded.
Limit State	A limit state is a possible failure mode for the pipeline.
Limit States Design	Design approach in which the failure modes are addressed explicitly, and it is checked that the design margins are adequate to cover the uncertainties involved.
Load and Resistance Factor Design (LRFD)	Design according to a set of rules in which safety factors are applied on both the load and the resistance, and may also be applied to other parameters used in the design assessment. (The use of several factors instead of just one provides more flexibility to calibrate these factors to achieve a consistent level of reliability for all design cases to which the rules apply.) This could be a pre-calibrated Reliability-based Limit States Design, or a design format in which the safety margins to cover uncertainties are established based on experience and engineering judgement. In the former case, Reliability-Based Limit States Design is used to develop a set of design rules, whereby a stated reliability level is achieved. Developing the design rules requires the failure probability to be calculated for every possible way in which these rules could be used, in order to check that the failure probability is tolerable for all allowed applications of the rules. Generally, the resulting design rules will involve safety factors on both loads and resistances, and following them is called load-and-resistance-factor design (LRFD). In the latter case, an LRFD procedure is calibrated based on experience and engineering judgement, rather than probability calculations.

Term	Definition
Of the Order Of	For quantities A and B, A is of the order of B, if the ratio A/B remains finite and bounded even for extreme cases of the parameters that can affect A and B. For instance, the statement that “size L of the region of influence is of the order of $(Dt)^{1/2}$ ” means that the ratio $L/(Dt)^{1/2}$ remains finite and bounded even if D/t becomes very large.
Potential Failure Point	Corresponds to the conditional expected value of the basic variables given that failure occurs. In standard Monte Carlo simulations (without importance sampling), this is calculated by taking the average value of the random variables for the simulations that lead to failure. (See also “Design Point” defined in Part III-3.8)
Quantitative Risk Assessment (QRA)	An assessment of the failure probability together with an assessment of the consequences of failure to define the risk, which itself is defined as the product of failure probability or frequency multiplied by the consequences of a failure.
Relevant	Having a significant influence on the reliability of the pipeline.
Reliability-based Limit States Design	Limits states design in which quantitative uncertainties affecting each limit state are used to calculate a failure probability, and to check that this failure probability remains below a tolerable level.
Section Strain	Strain that includes concentration effects that affect a region of size of the order of the pipe diameter, but not concentration effects resulting in more local strain concentrations
Section Stress	Stress corresponding to the Section Strain.
Stochastic Range	Represents a continuous range of values for a real-valued random variable with a specified probability that the outcome falls outside the range for the upper and lower sides.
Structural Reliability Assessment (SRA)	An assessment of a system in regard to one or more specific limits states, by constructing a limit state function, estimating the uncertainties in both the inputs to the model itself, and combining these systematically according to probability theory to calculate the failure probability.
Target Reliability Level	Tolerable Failure Probability
Tolerable Failure Probability	Maximum failure probability that is tolerated; may be different for different failure modes depending on the classification adopted in accordance with (Part III-8).

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (Part IV).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2016. The only changes are to DEP cross-references to reflect changes in the DEP library in 2017. The following are the main, non-editorial changes.