DEP SPECIFICATION

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

DEP 31.40.10.18-Gen.

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DESIGN AND ENGINEERING PRACTICE

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PART I INTRODUCTION AND GENERAL REQUIREMENTS

1. INTRODUCTION

1.1 SCOPE

This new DEP applies when the option in ISO 13623:2009 Clause 6.1 to apply "reliability-based limit states design methods" is invoked. This DEP provides requirements for the application of such methods.

This DEP is based on ISO 16708:2006. Part II 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.

Where cross-references to other parts of this DEP are made, the Part number ("I", "II", or "III") is given followed (without a space) by a hyphen and the Clause number. For instance "II-6.2" refers to Clause 6.2 in Part II. Where the part number is left out, it refers to a clause in ISO 16708:2006 that is not amended by this DEP.

Clauses of ISO 16708:2006 not modified by this DEP remain applicable 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.

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.

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.

If national and/or local regulations exist in which some of the requirements may 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 regard 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, 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 **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may include an agent or consultant authorised to act for and on behalf of the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

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1.3.2 Specific definitions

In addition to the following definitions, those from ISO 16708:2006 as amended in (II-3) also apply. Some of the definitions contain references to notes that appear at the end of this section, e.g. giving an example of the 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 which of design methods described under (II-5), i.e. LRFD, SRA or QRA, is to be used for which limit state, in such a way that all relevant limit states and uncertainties are covered, and includes criteria for each case, with tolerable failure probabilities where applicable, either directly or by reference on one or more Design Specification Documents.
Design Specification	Document containing a detailed specification of criteria to be applied in the design for specific limit state(s) and loading conditions; this may be based on probabilistic or deterministic criteria, but in either case shall contain a position on relevant engineering judgments, 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 judgment. (E.g. if the 100-year wave height at a specific location is one of the inputs to the design check, the two referenced engineers may differ on how they arrive at this parameter from the available information, hindcast simulations, etc.)
Effective Value	The effective value of an input parameter to the limit sates function is the value for which the selected limit states function yields the correct prediction in regard to specified uncertainties. (Note 1)
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. (Note 2)

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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.)
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 II-3.8)
Relevant	Having a significant influence on the reliability of the pipeline.
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.
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.
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.
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. (Note 3)
Section Stress	Stress corresponding to the Section Strain.
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 (II-8).

NOTES: 1) As an example of an effective value, suppose the effect of lateral buckling of a pipeline is being assessed using a simple frictional model for pipe-soil interaction under lateral movements. The lateral friction coefficient is then the input parameter to the limit states function. In reality the simple friction model is only an approximation, e.g. because with increasing lateral displacements the lateral resistance increases as a soil berm develops by the sweeping action of the pipeline, or because the soil properties are changing along the length of the buckle so that there is no single relevant friction factor, or because the seabed is not quite flat and therefore more lateral

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resistance at high than at low points. To account for such complexity in a simple manner, an effective value can be defined for the friction coefficient used in the limit states function such that it yields the correct peak strain in the pipeline. Here "correct" means the same value as would be obtained if the actual soil resistance with all its complexity had been modelled exactly. The effective value depends not only the physical conditions, but also on the limit states function used, and on the specified uncertainties that it captures.

2) The definition of z as the equivalent standard normal value corresponding to a value x of a random variable X implies that $z = \Phi^{-1}(F(x))$, where $\Phi^{-1}(.)$ is the inverse cumulative distribution function for the standard normal distribution, and F(.) is the cumulative distribution function for the random variable X. As an example, the value of X corresponding to an equivalent standard normal value of 2 has a probability of being exceeded of 2.3 %; if X is normally distributed, this corresponds to a mean-plus-two-standard-deviations value of X.

3) In practice the section strain represents that a strain in the pipeline that can be calculated using a formulation that is based on the assumption of beam theory that plane sections of the pipe remain plane. This is because such models can capture sources of strain concentration that affect region of the order of one pipe diameter in size, but not more local concentrations, for which the pipe would need to be modelled as a shell or as a solid (three-dimensional continuum).

1.4 ABBREVIATIONS

LRFD Load and Resistance Factor Design

QRA Quantitative risk assessment

SRA Structural Reliability Analysis

1.5 CROSS-REFERENCES

Cross-references to other parts of this DEP, or to ISO 16708:2006, are made as described in (II-2.1) and are placed in brackets. Other documents referenced by this DEP are listed in (III).

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal http://sww.shell.com/standards and on the main page of the DEPs DVD-ROM.

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