SIST

SLOVENSKI STANDARD
oSIST prEN ISO 19901-2:2025

01-januar-2025

Naftna in plinska industrija, vključno z nizkoogljično energijo - Posebne zahteve za naftne ploščadi - 2. del: Postopki potresno varnega projektiranja in potresna merila (ISO/DIS 19901-2:2024)

Oil and gas industries including lower carbon energy - Specific requirements for offshore structures - Part 2: Seismic design procedures and criteria (ISO/DIS 19901-2:2024)

Erdöl- und Erdgasindustrie - Spezielle Anforderungen für Offshore-Anlagen - Teil 2: Seismische Auslegungsverfahren und -kriterien (ISO/DIS 19901-2:2024)

Industries du pétrole et du gaz, y compris les énergies à faible teneur en carbone - Exigences spécifiques relatives aux structures en mer - Partie 2: Procédures de conception et critères sismiques (ISO/DIS 19901-2:2024)

Ta slovenski standard je istoveten z: prEN ISO 19901-2

ICS:

75.180.10	Oprema za raziskovanje, vrtanje in odkopavanje	Exploratory, drilling and extraction equipment
91.120.25	Zaščita pred potresi in vibracijami	Seismic and vibration protection

oSIST prEN ISO 19901-2:2025 en,fr,de

DRAFT International Standard

ISO/DIS 19901-2

ISO/TC **67**/SC **7**

Secretariat: **BSI**

Voting begins on:
2024-11-11

Voting terminates on:
2025-02-03

Oil and gas industries including lower carbon energy — Specific requirements for offshore structures —

Part 2: Seismic design procedures and criteria

ICS: 75.180.10

This document is circulated as received from the committee secretariat.

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/DIS 19901-2:2024(en)

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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.

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 7, *Offshore structures,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 12, *Oil and gas industries including lower carbon energy,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the second edition (ISO 19901-2:2022), which has been technically revised.

The main changes are as follows:

— scope expanded to cover offshore wind and other renewable energy offshore structures;

— incorporates requirements from common industry specifications (IOGP JIP 35);

— the seismic hazard maps have been updated;

— written with clear and concise requirements.

A list of all parts in the ISO 19901 series can be found on the ISO website.

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 Standards on offshore structures prepared by TC 67 address design requirements and assessments of all offshore structures used in the energy sector worldwide. Through their application, the intention is to achieve reliability levels appropriate for normally occupied and normally unoccupied offshore structures, whatever the type of structure and the nature or combination of the materials used.

Structural integrity is an overall concept comprising models for describing actions, structural analyses, design or assessment rules, safety elements, workmanship, quality control procedures and national requirements, all of which are mutually dependent. The modification of one aspect of design or assessment in isolation can disturb the balance of reliability inherent in the overall concept or structural system. The implications involved in modifications, therefore, need to be considered in relation to the overall reliability of all offshore structural systems.

The International Standards on offshore structures prepared by TC 67 are intended to provide a wide latitude in the choice of structural configurations, materials, and techniques without hindering innovation. Sound engineering judgement is, therefore, necessary in the use of these International Standards.

The overall concept of structural integrity is described above. Some additional considerations apply for seismic design. These include the magnitude and probability of seismic events, the use and importance of the offshore structure, the robustness of the structure under consideration and the allowable damage due to seismic actions with different probabilities. All of these, and any other relevant information, need to be considered in relation to the overall reliability of the structure.

Seismic conditions vary widely around the world, and the design criteria depend primarily on observations of historical seismic events together with consideration of seismotectonics and local soil conditions. In many cases, site-specific seismic hazard assessments will be required to complete the design or assessment of a structure.

This document is intended to provide general seismic design procedures for different types of offshore structures, and a framework for the derivation of seismic design criteria. Further requirements are contained within the general requirements International Standard, ISO 19900, and within the structure-specific International Standards, ISO 19902, ISO 19903, ISO 19904, and ISO 19906. The consideration of seismic events in connection with mobile offshore units is addressed in ISO 19905.

Oil and gas industries including lower carbon energy — Specific requirements for offshore structures —

Part 2: Seismic design procedures and criteria

1 Scope

This document contains provisions for seismic design and assessment of offshore structures.

Recommendations for the effects of seismic events on floating structures are introduced.

Design and assessment of earthquake-induced ground motions are specifically addressed. Other geologically induced hazards such as liquefaction, slope instability, faults, tsunamis, mud volcanoes and shock waves are briefly covered.

Provisions for site-specific probabilistic seismic hazard analysis are provided for offshore structures in high seismic areas and for offshore structures with high consequence levels.

NOTE Guidance and background information relating to the requirements is included in Annex A.

2 Normative references

The following documents are referred to in the text in such a way that some or all 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 19900, *Oil and gas industries including lower carbon energy — General requirements for offshore structures*

3 Terms and definitions (Pending)

For the purposes of this document, the terms and definitions given in ISO 19900 and the following 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
abnormal level earthquake
ALE
intense earthquake of abnormal severity with a very low probability of occurring during the life of the structure, generally of return period in the 1 000's of years.

Note 1 to entry: The ALE event is comparable to the abnormal event in the design of fixed structures that are described in ISO 19902[6] and ISO 19903[7].

3.2
attenuation
decay of seismic waves as they travel from the earthquake source to the site under consideration.

3.3
deaggregation
separation of seismic hazard contribution from different faults and seismic source zones

3.4
escape and evacuation system
system provided on the offshore structure to facilitate escape and evacuation in an emergency.

EXAMPLE Passageways, chutes, ladders, life rafts and helidecks.

3.5
extreme level earthquake
ELE
strong earthquake with a reasonable probability of occurring during the life of the structure, generally of return period in the 100's of years.

3.6
fault movement
movement occurring on a fault during an earthquake.

3.7
ground motion
accelerations, velocities or displacements of the ground produced by seismic waves radiating away from earthquake sources.

Note 1 to entry: A fixed offshore structure is founded in or on the *seabed* (3.17) and consequently only seabed motions are of significance. The expression "ground motions" is used rather than seabed motions for consistency of terminology with seismic design for onshore structures.

Note 2 to entry: Ground motions can be at a specific depth or over a specific region within the seabed.

3.8
liquefaction
fluidity of soil due to the increase in pore pressures caused by earthquake action under undrained conditions.

3.9
modal combination
combination of response values associated with each dynamic mode of a structure.

3.10
mud volcano
diapiric intrusion of plastic clay causing high pressure gas-water seepages which carry mud, fragments of rock (and occasionally oil) to the surface.

Note 1 to entry: The surface expression of a mud volcano is a cone of mud with continuous or intermittent gas escaping through the mud.

3.11
probabilistic seismic hazard analysis
PSHA
framework permitting the identification, quantification, and rational combination of uncertainties in earthquakes' intensity, location, rate of recurrence and variations in *ground motion* (3.7) characteristics.

3.12
probability of exceedance
probability that a variable (or that an event) exceeds a specified reference level given exposure time.

EXAMPLE The annual probability of exceedance of a specified magnitude of ground acceleration, ground velocity or ground displacement.

3.13
response spectrum
maximum responses of a series of single-degree-of freedom systems subjected to a given base motion, plotted as a function of natural frequencies for specific values of damping.

3.14
safety system
systems provided on the offshore structure to detect, control and mitigate hazardous situations.

EXAMPLE Gas detection, emergency shutdown, fire protection, and their control systems.

3.15
sea floor
interface between the sea and the *seabed* (3.17)

3.16
seabed slide
failure of *seabed* (3.17) slopes

3.17
seabed
soil material below the sea in which a structure is founded.

3.18
seismic risk category
SRC
category defined from the consequence level and the intensity of seismic motions (i.e., the spectral acceleration having an annual probability of exceedance of 1/1 000).

3.19
seismic hazard curve
curve showing the annual *probability of exceedance* (3.12) against a measure of seismic intensity.

Note 1 to entry: The seismic intensity measures can include parameters such as peak ground acceleration, *spectral acceleration* (3.22), or *spectral velocity* (3.23).

3.20
seismic reserve capacity factor
factor indicating the structure's ability to sustain ground motions due to earthquakes beyond the level of the *extreme level earthquake* (3.5)

Note 1 to entry: Refer to A.9.3.6 for more detail.

3.21
site response analysis
wave propagation analysis permitting the evaluation of the effect of local geological and soil conditions on the *ground motions* (3.7) as they propagate up from depth to the surface at the site.

3.22
spectral acceleration
maximum absolute acceleration response of a single degree of freedom oscillator subjected to *ground motions* (3.7) due to an earthquake.

3.23
spectral velocity
maximum pseudo velocity response of a single degree of freedom oscillator subjected to *ground motions* (3.7) due to an earthquake.

Note 1 to entry: The pseudo velocity spectrum is computed by factoring the displacement or acceleration spectra by the oscillator's circular frequency or the inverse of its frequency, respectively.

3.24
spectral displacement
maximum relative displacement response of a single degree of freedom oscillator subjected to *ground motions* (3.7) due to an earthquake.

3.25
static pushover analysis
application and incremental increase of a global static pattern of actions on a structure, including equivalent dynamic inertial actions, until a global failure mechanism occurs.

3.26
tsunami
long period sea waves caused by rapid vertical movements of the *sea floor* (3.15)

Note 1 to entry: The vertical movement of the sea floor is often associated with fault rupture during earthquakes or with *seabed slides* (3.16).

4 Symbols and abbreviated terms (Pending)

4.1 Symbols

a_R tail slope of the seismic hazard curve

C_a site coefficient, a correction factor applied to the acceleration part (shorter periods) of a response spectrum

C_c correction factor applied to the spectral acceleration to account for uncertainties not captured in a seismic hazard curve

C_r seismic reserve capacity factor; see Formulae (7) and (10)

C_v site coefficient, a correction factor applied to the velocity part (longer periods) of a response spectrum

D scaling factor for damping

G_{max} initial (small strain) shear modulus of the soil

g acceleration due to gravity

M magnitude of an earthquake measured by the energy released at its source

N_{ALE} scale factor for conversion of the site 1 000-year acceleration spectrum to the site ALE acceleration spectrum

p_a atmospheric pressure

P_{ALE} annual probability of exceedance for the ALE event

P_e probability of exceedance

P_{ELE} annual probability of exceedance for the ELE event

P_f target annual probability of failure

q_c cone penetration resistance of soil

q_{cl} normalized cone penetration resistance of soil

$\bar{q}$_"cl" average normalized cone penetration resistance of sand in the effective seabed

$S_a(T)$	spectral acceleration associated with a single degree of freedom oscillator period, T
T	mean spectral acceleration associated with a single degree of freedom oscillator period, T; obtained from a PSHA
$S_{a,ALE}(T)$	is the spectral acceleration for a single degree of freedom oscillator period T resulting from a suite of time histories that, when the structure is exposed to, would result in a probability of collapse of 50 %.
$S_{a,ELE}(T)$	ELE spectral acceleration associated with a single degree of freedom oscillator period, T
$S_{a,map}(T)$	1 000-year rock outcrop spectral acceleration obtained from maps associated with a single degree of freedom oscillator period, T
$S_{a,P_e}(T)$	mean spectral acceleration associated with a probability of exceedance, P_e, and a single degree of freedom oscillator period, T, obtained from a PSHA
$S_{a,P_{NC}}(T)$	spectral acceleration having an annual probability of associated with a target annual probability of failure, P_f, and a single degree of freedom oscillator period, T, obtained from a PSHA
$S_{a,site}(T)$	site spectral acceleration corresponding to a return period of 1 000 years and a single degree of freedom oscillator period, T
s_u	undrained shear strength of the soil
$\bar{s}_u$	average undrained shear strength of the soil in the effective seabed
T	natural period of a simple, single degree of freedom oscillator
T_{dom}	dominant modal period of the structure
T_{return}	return period
v_s	representative shear wave velocity
	average of representative shear wave velocity in the effective seabed
ρ	mass density of soil
η	per cent of critical damping
σ_{LR}	logarithmic standard deviation of uncertainties not captured in a seismic hazard curve
σ'_{v0}	in situ vertical effective stress of soil

4.2 Abbreviated terms

DL	damage limitation limit state
DSHA	deterministic seismic hazard analysis
DSRA	dynamic site response analysis
L1, L2, L3	consequence level derived in ISO 19900
MOU	mobile offshore unit
NC	near collapse limit state
NP	nonlinear pushover

NTHA	nonlinear time history analysis
PGA	peak ground acceleration
RP	return period
THA	time history analysis
TLP	tension leg platform
ULS	ultimate limit state

5 Seismic hazards

5.1 Seismic design and assessment of offshore structures **shall** include the effect of ground motions due to earthquakes.

5.2 The design and assessment of offshore structures **shall** also include the effects of the following seismic hazardous events, as developed by specialists in geologic site hazards:

a) soil liquefaction.

b) seabed slide.

c) fault movement.

d) tsunamis.

e) mud volcanoes.

f) velocity pulse from directivity effects.

6 Performance objectives, limit states and damage states

6.1 General

6.1.1 The risks, due to the structure being exposed to seismic hazardous events, **shall** be demonstrated to be tolerable in conformance with 6.1.2 to 6.1.5.

NOTE 19901-2 requirements will result in the structure having sufficient strength and ductility such that the risks (life-safety, environmental-pollution, and business-disruption) are tolerable when the structure is exposed to seismic hazardous events as defined by the hazard curve for the site.

6.1.2 The structure **shall** meet the performance objectives (as defined in 6.3).

6.1.3 Demonstration that the structure meets the performance objectives **shall** be by limit state verification in conformance with ISO 19900.

6.1.4 The performance objective for life-safety risk, typically associated with the ALE, **shall** specify the maximum tolerable annual probability that the (damage) state of structure can exceed the Near Collapse (NC) limit state.

NOTE 1 the NC limit state is described in 6.2.1. When the state of the structure is at the NC limit state, the structural system remains stable, but one or more components can have failed. Since the structure remains stable and does not collapse, fatalities are limited or avoided following the seismic event, and thus the life- life-safety consequence is negligible