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Oil and gas industries including lower carbon energy — Offshore structures —

Part 8: Marine soil investigations

Industries du pétrole et du gaz y compris les énergies à faible teneur en carbone — Structures en mer —

Partie 8: Investigations des sols en mer

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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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, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 19901-8:2014), which has been technically revised.

The main changes are as follows:

— application classes for in situ testing tools are removed and replaced by an assessment of documented calibration results and uncertainty analyses;

— new procedures for calibration and verification of cone penetrometers are introduced with reference to the latest edition of ISO 22476-1.

— references to project specifications for technical details have been reduced where possible and roles and responsibilities have been further clarified.

— title and scope change adopted as per Technical Management Board Resolution 53/2022.

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/SC 7 (ISO 19900, the ISO 19901 series, ISO 19902, ISO 19903, ISO 19904, ISO 19905 series and ISO 19906) constitute a common basis covering those aspects that address design requirements and assessments of all offshore structures used by the petroleum and natural gas industries worldwide. Through their application, the intention is to achieve reliability levels appropriate for manned and unmanned offshore structures, whatever the nature or combination of the materials used. Application specific requirements for different energy industries are referencing relevant overarching standards. For example, for the offshore wind industry the IEC standards IEC 61400-1 and IEC 61400-3-1 outline the normative design requirements (e.g. return periods) for offshore turbine support structures.

Structural integrity is a concept comprising models for describing actions, structural analyses, design rules, safety elements, workmanship, quality control procedures and national requirements, all of which are mutually dependent. The modification of one aspect of design in isolation can disturb the balance of reliability inherent in the overall concept of structural integrity (see ISO 19900). The implications involved in modifications, therefore, should be considered in relation to the overall reliability of all offshore structural systems.

A marine soil investigation is only one of many possible marine site investigations as illustrated in Figure 1. The scope of a marine soil investigation, such as field programme, equipment to be used, laboratory testing programme, soil parameters to be established and reporting, is usually defined in project specifications based on important factors, such as type of structures involved, type of soil conditions expected, regional or site-specific investigation, preliminary or final soil investigations. The reporting can comprise anything from field data only to reporting of soil parameter values.

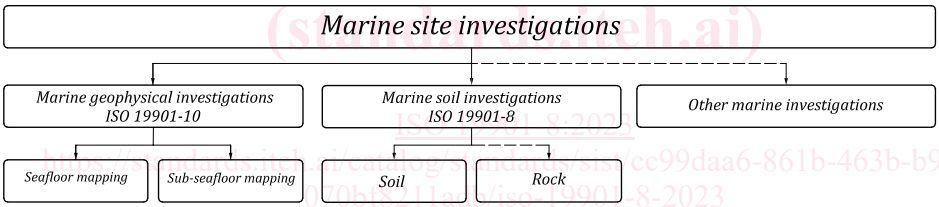

Figure 1 — Marine soil investigations shown as one of many types of marine site investigations.

Use of this document is based on the following assumptions:

— communication takes place between geophysical and geotechnical specialists for defining the scope of the marine soil investigation based on the results of a geophysical investigation (see ISO 19901-10);

— communication takes place between geotechnical personnel involved in marine soil investigations and the personnel responsible for foundation design, for construction and for installation of the offshore structures;

— soil data are collected, documented and interpreted by trained personnel;

— the project-specific scope of work for marine soil investigations is defined by one or more project specifications.

The detailed requirements for equipment and methods given in this document are only applicable if relevant for the scope of work defined in the project specifications.

This document is intended to provide flexibility in the choice of marine soil investigation techniques without hindering innovation.

In this document, the following verbal forms are used:

— "shall" indicates a requirement;

— “should” indicates a recommendation;

— “can” indicates a possibility or a capability;

— “may” indicates a permission.

Information marked as “NOTE” is intended to assist the understanding or use of the document. “Notes to entry” used in Clause 3 provide additional information that supplements the terminological data and can contain requirements relating to the use of a term.

Annex A gives additional information intended to assist the understanding or use of this document. The clause numbers in Annex A correspond to the normative main text to facilitate easy cross-referencing. Annex B covers conduct of laboratory tests as part of marine soil investigations.

Oil and gas industries including lower carbon energy — Offshore structures —

Part 8: Marine soil investigations

1 Scope

This document specifies requirements and provides recommendations and guidelines for marine soil investigations regarding:

a) objectives, planning and execution of marine soil investigations;

b) deployment of investigation equipment;

c) drilling and logging;

d) in situ testing;

e) sampling;

f) laboratory testing;

g) reporting.

Although this document focuses on investigations of soil, it also provides guidance, with less detail, for investigations of chalk, calcareous soils, cemented soils and weak rock.

Foundation design is not covered by this document.

NOTE 1 ISO 19901-4 and the respective design standards covering foundation design for the specific types of offshore structures to meet the requirements of application specific standards are given on the ISO website.

The results from marine geophysical investigations are, when available and where appropriate, used for planning, optimization and interpretation of marine soil investigations.

This document neither covers the planning, execution and interpretation of marine geophysical investigations nor the planning and scope of geohazard assessment studies, only the corresponding marine soil investigations aspects thereof.

NOTE 2 ISO 19901-10 covers the planning, execution and interpretation of marine geophysical investigations.

This document specifies requirements and provides guidance for obtaining measured values and derived values. This document excludes requirements for determination of design values and representative values. Limited guidance is provided in 11.3 related to data interpretation.

This document is intended for clients, soil investigation contractors, designers, installation contractors, geotechnical laboratories and public and regulatory authorities concerned with marine soil investigations for any type of offshore structures, or geohazard assessment studies.

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 14688-1, *Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description*

ISO 14688-2, *Geotechnical investigation and testing — Identification and classification of soil — Part 2: Principles for a classification*

ISO 14689, *Geotechnical investigation and testing — Identification, description and classification of rock*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO 19900, *Petroleum and natural gas industries — General requirements for offshore structures*

ISO 22476-1, *Geotechnical investigation and testing — Field testing — Part 1: Electrical cone and piezocone penetration test*

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14688-1, ISO 14688-2, ISO 14689 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
accuracy
closeness of agreement between a measured quantity value and a true quantity value of a measurand

[SOURCE: ISO/IEC Guide 99:2007, 2.13]

3.2
borehole geophysical logging
measurement of physical properties of a borehole and/or the surrounding soil, obtained by one or more logging probes deployed in the borehole

3.3
client
party or person with overall responsibility for the marine soil investigation, including preparation of project specifications

3.4
coordinate reference system
coordinate system that is related to an object by a datum

Note 1 to entry: Geodetic and vertical datums are referred to as reference frames.

3.5
contractor
party or person responsible for an assigned scope of work described in project specifications

3.6
derived value
value of a geotechnical parameter obtained from test results by theory, correlation or empiricism

3.7
design value
value derived from the representative value for use in the design verification

[SOURCE: ISO 19900:2019, 3.14]

3.8
disturbed sample
sample whose soil structure, water content and/or constituents have changed as a result of sampling and handling

3.9
drained condition
condition whereby the applied stresses and stress changes are supported entirely by the soil skeleton and do not cause a change in pore pressure

3.10
drilling mud
drilling fluid
fluid pumped down a rotary drilled borehole to facilitate the drilling process

Note 1 to entry: The hardware associated with handling drilling fluids is commonly prefixed 'mud' (e.g. mud tank, mud pump, mud valve). Drilling parameters associated with drilling fluids are similarly prefixed (mud pressure, mud flow, etc.).

3.11
geohazard
geological condition that has the potential to have adverse effects on persons, operations, offshore structures or the environment

3.12
ground model
2- or 3-dimensional representation of the seafloor (bathymetry) and, where applicable, the sub-seafloor conditions, at a given time, that is specific to the offshore structure(s) considered

3.13
ground truthing
integration of seafloor or sub-seafloor geophysical data with data acquired by marine soil investigation and other data

3.14
in-pipe logging
borehole geophysical logging (3.2) in a section of the borehole with drill pipe between the tool and the borehole wall

Note 1 to entry: The number of parameters that can be usefully measured in these circumstances is restricted.

3.15
inclination
the angular deviation of the cone penetrometer from the vertical.

3.16
intact sample
sample that was collected with intention to preserve its in situ characteristics

3.17
integrated geoscience study
combination of geophysical data, a model for geological processes and geotechnical data for development of a *ground model* (3.12)

3.18
marine geophysical investigation
type of marine site investigation of seafloor or sub-seafloor that uses non-destructive methods requiring marine deployment of geophysical tools

Note 1 to entry: See Figure 1.

3.19
marine site investigation
type of investigation at an offshore or nearshore site

EXAMPLE Marine soil investigation, marine geophysical investigation, marine biological investigation, metocean investigation. See Figure 1.

3.20
marine soil investigation
type of *marine site investigation* (3.19) whose primary objective is to obtain reliable and representative soil data for characterization of the seabed soil conditions to facilitate the design of offshore structures and/or for *geohazard* (3.11) evaluation

Note 1 to entry: See Figure 1 and ISO 19901-10.

3.21
measured value
value that is measured in a test

3.22
nominal value
value assigned to a variable specified or determined on a non-statistical basis, typically acquired experience or physical conditions, or as published in a recognized code or standard

3.23
open-hole logging
borehole geophysical logging (3.2) in a section of the borehole without, for example, casing or drill pipe between the tool and the borehole wall

3.24
project specification
scope of work for *marine soil investigations* (3.20) assigned by the *client* (3.3) to a *contractor* (3.5)

3.25
rat hole
additional depth drilled at the end of the borehole (beyond the last zone of interest) to ensure that the zone of interest for *borehole geophysical logging* (3.2) can be fully evaluated

Note 1 to entry: The rat hole allows tools at the top of the logging string to reach and measure the deepest zone of interest.

3.26
reconstituted specimen
laboratory specimen prepared by mixing a soil sample to specified state using a specified procedure

3.27
remoulded sample
remoulded specimen
laboratory specimen that is thoroughly reworked mechanically at a constant water content

3.28
remoulded shear strength
shear strength of remoulded soil

3.29
representative value
value assigned to a basic variable for verification of a limit state in a design/assessment situation

[SOURCE: ISO 19900:2019, 3.40]

3.30
residual shear strength
shear strength at large strains where shear stress versus strain levels off to a constant value

3.31
sample
portion of soil or rock recovered from the seabed by sampling techniques

3.32
sample quality
classification of soil *samples* (3.31) and specimens based on qualitative or quantitative techniques for assessment of the degree of inevitable disturbance induced by the sampling, transportation, handling and storage processes

Note 1 to entry: Sample quality criteria for low to medium OCR clays, where the sample quality is based on measured volume change from laboratory consolidation tests, are given in Table 9.

3.33
seabed
materials below the seafloor

Note 1 to entry: Sub-seafloor can also be used as an equivalent term (See ISO 19901-10).

3.34
seafloor
interface between the sea and the *seabed* (3.33)

3.35
settlement
elastic or permanent downward movement of a structure as a result of its own weight and other actions

3.36
site
defined investigation area, including vertical extent.

3.37
soil parameter
soil property that can be quantified by a descriptor or a value

Note 1 to entry: Cone resistance and undrained shear strength are examples of soil parameters; low strength and very dense are examples of descriptors; nominal value, measured value and derived value are examples of types of values that can be determined for a soil parameter.

3.38
specimen
part of a *sample* (3.31) used for a laboratory test

3.39
strength index test
test that yields an indication of the shear strength

3.40
swelling
expansion due to reduction of effective stress, resulting from either reduction of total stress or absorption of (in general) water at constant total stress

Note 1 to entry: Swelling includes the reverse of both compression and consolidation.

Note 2 to entry: Exsolution of dissolved gas due to stress relief during sampling can cause significant swelling in samples.

3.41
taper angle
rate, in degrees, at which the outside diameter of the sampler cutting shoe reduces

3.42
uncertainty
non-negative parameter that characterizes the dispersion of the quantity values that are being attributed to a measurand

[SOURCE: ISO/IEC Guide 99:2007, 2.26]

3.43
undisturbed sample
sample (3.31) in which no change of practical significance has occurred in the soil characteristics

3.44
undrained condition
condition whereby the applied stresses and stress changes are supported by both the soil skeleton and the pore fluid and do not cause a change in volume

3.45
undrained shear strength
maximum shear stress at yielding or at a specified maximum strain in an *undrained condition* (3.43)

Note 1 to entry: Yielding is the condition of a material in which a large plastic strain occurs at little or no stress increase.

4 Symbols, units and abbreviated terms

4.1 Symbols

A projected area of the miniature cone, T-bar or ball penetrometer

A_c nominal cross-sectional area of a cone penetrometer

A_n area of the load cell or shaft on which pore pressure can act

A_p projected area of the penetrometer in a plane normal to the shaft

A_s surface area of the friction sleeve

A_{sb} cross-sectional area of the bottom of the friction sleeve

A_{sp} cross-sectional area of the ball or T-bar penetrometer connecting shaft

A_{st} cross sectional area of the top of the friction sleeve

a net area ratio of a cone penetrometer, ball or T-bar penetrometer

B Skempton's pore pressure parameter

B_q	pore pressure ratio
b	net area ratio of the friction sleeve
C_A	area ratio of sampling tube
C_i	inside clearance ratio
C_c	compression index
c_v	coefficient of consolidation
c'	effective stress cohesion intercept
d_w	water depth
D	diameter of miniature penetrometer
D_i	inner diameter of sampling tube
D_o	outer diameter of sampling tube
D_1	diameter of miniature penetrometer in earlier test, for calculation of edge-to-edge test spacing
D_2	diameter of miniature penetrometer in later test, for calculation of edge-to-edge test spacing
e	void ratio
e_{min}	minimum void ratio
e_{max}	maximum void ratio
e_0	initial void ratio
F	measured axial force on the ball or T-bar relative to zero at seafloor
f_s	sleeve friction
F_r	friction ratio (= f_s/q_{net})
F_{thrust}	applied thrust to push rod
G	shear modulus
G_{max}	initial (small strain) shear modulus
G_s	specific gravity of solid particles
g	acceleration due to gravity (= 9,81 m/s^2),
H	specimen height
h_e	height of the cylindrical extension
h_s	height of drill pipe above main deck level
h_d	height of main deck level above the sea level
h_{sf}	height of reference point above seafloor
i	inclination of the cone penetrometer