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Petroleum and natural gas industries — Specific requirements for offshore structures —

Part 8: Marine soil investigations

Industries du pétrole et du gaz naturel — Exigences spécifiques relatives aux structures en mer —
Partie 8: Investigations des sols en mer

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, SC 7, *Offshore structures*.

ISO 19901 consists of the following parts, under the general title *Petroleum and natural gas industries — Specific requirements for offshore structures*:

— *Part 1: Metocean design and operating considerations*

— *Part 2: Seismic design procedures and criteria*

— *Part 3: Topsides structure*

— *Part 4: Geotechnical and foundation design considerations*

— *Part 5: Weight control during engineering and construction*

— *Part 6: Marine operations*

— *Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units*

— *Part 8: Marine soil investigations*

Introduction

The series of International Standards applicable to offshore structures, ISO 19900 to ISO 19906, constitutes 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.

It is important to recognize that 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. The implications involved in modifications, therefore, need to be considered in relation to the overall reliability of all offshore structural systems.

This part of ISO 19901 is applicable for marine soil investigation, which is only one of many possible marine site investigations as illustrated in Figure 1. The terminology used in Figure 1 and other important terminology are defined and given in Clause 3.

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 should be 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 parameters. An example report format is given in Annex G, Table G.1, but for each project the final reporting structure can be adjusted by deleting inapplicable sections, or by adding new sections.

This part of ISO 19901 gives requirements, recommendations and guidelines for the planning and execution of marine soil investigations and is applicable from the planning phase to reporting of soil parameters. It is important to use documented methods when soil parameters are established, and to refer to these methods in the report.

In situ and laboratory testing methods included in this part of ISO 19901 are selected based on their importance in marine soil investigation practice, availability in commercial geotechnical laboratories and the existence of an accepted testing procedure.

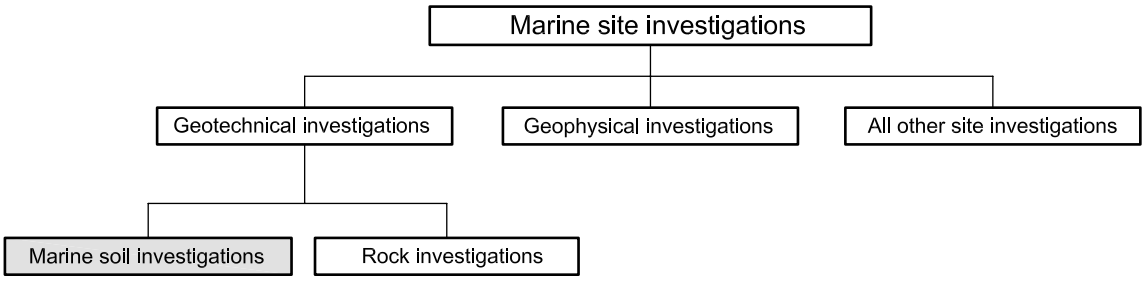

Figure 1 — Marine soil investigations shown as one of many types of marine site investigations

Seabed characterization can require several types of site investigations, for example marine soil investigations and geophysical investigations including geological and geohazard evaluations. For each project, the types of site investigations required are usually defined in project specifications. Also of importance for proper seabed characterization is consideration of required investigation equipment and its deployment mode(s) and methods, in order to acquire adequate quality soil data to the target depth.

This part of ISO 19901 is applicable for marine soil investigations at any water depth and to any depth below seafloor which can be reached with the tools used.

Use of this part of ISO 19901 is based on the assumptions that:

— adequate 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 parameters are collected, recorded and interpreted by qualified personnel;

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

Seabed soils can vary widely, and experience gained at one location is not necessarily applicable at another. The scope of a soil investigation for one type of structure is not necessarily adequate for another. Extra caution is therefore necessary when dealing with unconventional soils or unconventional foundation concepts. Marine soil investigations include both offshore and nearshore soil investigations, which can provide very different challenges.

The detailed requirements for equipment and methods given in this part of ISO 19901 are only applicable if relevant for the scope of work defined in the project specifications.

This part of ISO 19901 is intended to provide flexibility in the choice of soil investigation techniques without hindering innovation.

The primary objectives of this part of ISO 19901 are to provide requirements and guidance for how the most important aspects of a marine soil investigation should be performed to obtain reliable soil parameters based on documented methods.

In this part of ISO 19901, in accordance with the latest edition of the ISO/IEC Directives, Part 2, the following verbal forms are used:

— ‘shall’ and ‘shall not’ are used to indicate requirements strictly to be followed in order to comply with the document and from which no deviation is permitted;

— ‘should’ and ‘should not’ are used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited;

— ‘may’ and ‘need not’ are used to indicate a course of action permissible within the limits of the document;

— ‘can’ and ‘cannot’ are used for statements of possibility and capability, whether material, physical or causal.

This part of ISO 19901 includes informative annexes. Informative annexes give additional information intended to assist the understanding or use of the document. They do not contain requirements, except that informative annexes may contain optional requirements (for example a test method that is optional can contain requirements), but there is no need to comply with these requirements to claim compliance with this part of ISO 19901.

The following International Standards are also relevant to offshore structures for the petroleum and natural gas industries:

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

— ISO 19902, *Petroleum and natural gas industries — Fixed steel offshore structures*

— ISO 19903, *Petroleum and natural gas industries — Fixed concrete offshore structures*

— ISO 19904-1, *Petroleum and natural gas industries — Floating offshore structures — Part 1: Monohulls, semi-submersibles and spars*

— ISO 19905-1, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 1: Jack-ups*

— ISO/TR 19905-2, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 2: Jack-ups commentary*

— ISO 19906, *Petroleum and natural gas industries — Arctic offshore structures*

— ISO 13623, *Pipeline transportation systems*

— ISO 13628-1, *Design and operation of subsea production systems — Part 1: General requirements and recommendations*

Petroleum and natural gas industries — Specific requirements for offshore structures —

Part 8: Marine soil investigations

1 Scope

This part of ISO 19901 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; and

g) reporting.

Rock materials are only covered by this part of ISO 19901 to the extent that ordinary marine soil investigation tools can be used, e.g. for chalk, calcareous soils, cemented soils or similar soft rock.

Hard rock investigations are not covered by this part of ISO 19901; see F.13 for further guidance.

Foundation design is not covered by this part of ISO 19901, but by ISO 19901-4 and the respective design standards for the specific types of offshore structures as listed in the Foreword and Introduction.

Planning, execution and interpretation of geophysical investigations are not covered by this part of ISO 19901. However, the results from geophysical investigations should, where appropriate, be used for planning, optimization and interpretation of marine soil investigations.

This part of ISO 19901 does not cover the planning and scope of geohazard assessment studies, only the corresponding marine soil investigations aspects thereof.

Soil investigations from ice in Arctic regions are not covered by this part of ISO 19901.

This part of ISO 19901 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 and nearshore structures, or geohazard assessment studies, for petroleum and natural gas industries.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 22476-1:2012, *Geotechnical investigation and testing — Field testing — Part 1: Electrical cone and piezocone penetration test*

3 Terms and definitions

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

3.1
accuracy
exactness of a measurement compared to the true value of the quantity being measured

3.2
application class
classification of equipment based on achievable level of accuracy or classification of soil samples which can be used to determine various soil properties

Note 1 to entry: Application classes have been developed to provide guidance on equipment selection centred on the accuracy required when using the results.

Note 2 to entry: The term 'application class' in this part of ISO 19901 is called 'quality class' in 3.4.1 of EN 1997–2:2007 where the term 'application class' is not used. For the definition of 'quality class', see 3.24.

3.3
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

3.4
characteristic value
value assigned to a basic variable associated with a prescribed probability of not being violated by unfavourable values during some reference period

Note 1 to entry: The characteristic value is the main representative value. In some design situations a variable can have two characteristic values, an upper and a lower value.

[SOURCE: ISO 19900:2013, definition 3.10]

3.5
characterization
description, evaluation and/or determination of the most typical characteristics based on all types of site investigations and other available data

3.6
client
party or person with overall responsibility for the marine soil investigation, including preparation of project specifications

3.7
contractor
party or person responsible for an assigned scope of work described in project specifications

3.8
derived value
value of a geotechnical parameter obtained from test results by theory, correlation or empiricism

3.9
design value
value derived from the representative value for use in the design verification procedure

[SOURCE: ISO 19900:2013, definition 3.18]

3.10
disturbed sample
sample whose soil structure, water content and/or constituents have changed as a result of sampling and handling

3.11
drained condition
condition whereby the applied stresses and stress changes are supported by the soil skeleton and do not cause a change in pore pressure

3.12
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.).

3.13
geohazard
geological state and process that can cause material and environmental damage as well as loss of life

3.14
geophysical investigation
marine site investigation of seafloor or seabed by the use of non-destructive methods requiring marine deployment of geophysical tools

Note 1 to entry: See Figure 1 in Introduction.

3.15
ground truthing
process of using soil investigation data to characterize the various geological formations defined from geophysical investigations

3.16
in-pipe logging
logging in a section of the borehole or 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.

3.17
intact sample
sample that was collected with intention to preserve its in situ characteristics

3.18
marine site investigation
any type of investigation at an offshore or nearshore site

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

3.19
marine soil investigation
type of marine site investigation 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 evaluation

Note 1 to entry: See Figure 1 in Introduction.

Note 2 to entry: The scope of work and extent of a marine soil investigation varies from one project to another, but usually includes one or more of the items listed in Clause 1.

3.20
measured value
value that is measured in a test

3.21
nominal value
value assigned to a basic variable determined on a non-statistical basis, typically from acquired experience or physical conditions

3.22
open-hole logging
logging in a section of the borehole without, for example, casing or drill pipe, allowing a direct measurement of the soil properties outside the borehole wall to be made

3.23
project specification
scope of work for marine soil investigations assigned by the client to a contractor

3.24
quality class
classification of sample quality for low to medium OCR clays, where the sample quality is based on measured volume change from laboratory consolidation tests

Note 1 to entry: Exact definitions of the various sample quality classes are given in 10.5, Table 6.

Note 2 to entry: The definition of 'quality class' given in this part of ISO 19901 differs from the definition of 'quality class' given in 3.4.1 of EN 1997–2:2007. What is called 'quality class' in EN 1997–2:2007 is called 'application class' in this part of ISO 19901, see 3.2. The term 'application class' is not used in EN 1997–2:2007.

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 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

Note 1 to entry: For fine-grained soils, the specimen is prepared as a slurry (at or above the liquid limit) and then consolidated. For coarse-grained soils, it is either poured or pluviated in dry (dried) or wet conditions and compacted, or consolidated.

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

3.28
remoulded shear strength
shear strength measured on a remoulded specimen

3.29
representative value
value assigned to a basic variable for verification of a limit state

[SOURCE: ISO 19900:2013, definition 3.38]

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

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

3.32
seabed
materials below the seafloor

3.33
seafloor
interface between the sea and the seabed

3.34
settlement
permanent downward movement of a structure as a result of its own weight and other actions

3.35
site
defined investigation area

3.36
soil [geotechnical] parameter
measured, derived or representative soil [geotechnical] parameter

Note 1 to entry: The term 'geotechnical' includes both soil and rock.

3.37
specimen
part of a sample used for a laboratory test

3.38
strength index test
test that yields an indication of the shear strength

3.39
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.

3.40
uncertainty
reliability of the measurement results due to sources of systematic and random errors

3.41
undisturbed sample
sample in which no change of practical significance has occurred in the soil characteristics

3.42
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

3.43
undrained shear strength
maximum shear stress at yielding or at a specified maximum strain in an undrained condition

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

Note 2 to entry: Strain softening is also to be considered.

4 Symbols, units and abbreviated terms

4.1 Symbols

a	net area ratio of a cone penetrometer
c_v	coefficient of consolidation
C_s	swelling index (for consolidation tests)
h_{sf}	height of reference point above seafloor
f_s	sleeve friction
G	specific gravity of solid particles
G_{max}	initial (small strain) shear modulus
I_L	liquidity index
I_P	plasticity index
i	inclination
K_0	coefficient of earth pressure at rest (= $\sigma'_{h0}/\sigma'_{v0}$)
m_v	coefficient of compressibility
p_0'	*in situ* vertical effective stress (=σ'_{v0})
q_c	cone resistance
q_t	cone resistance corrected for pore water pressure effects
s	vane blade thickness
$s_u = c_u$	undrained (undisturbed) shear strength of soil
s_{uC}	static triaxial compression undrained shear strength
s_{uD}	static DSS undrained shear strength
s_{uE}	static triaxial extension undrained shear strength
s_{ufv}	shear strength by field vane testing
$s_{ufv,rem}$	remoulded shear strength by field vane testing
$s_{ufv,res}$	residual shear strength by field vane testing
S_t	soil sensitivity
u_2	pore pressure measured through a filter location in the cylindrical cone part just above conical part
v_p	compression wave velocity
v_s	shear wave velocity
v_{vh}	vertically (v) propagated, horizontally (h) polarized shear wave velocity

ξ	material damping ratio
z	height above seafloor for drilling mode *in situ* probe zero reference readings
γ'	submerged unit weight of soil
ν	Poisson's ratio
σ	stress
σ'_{v0}	*in situ* vertical effective stress (= p_0')
σ'_{h0}	*in situ* horizontal effective stress
σ'_{p}	preconsolidation stress
$\Delta\sigma'_{v}$	change in effective vertical stress
ϕ'	effective angle of internal friction

4.2 Units

Units to be used can vary somewhat from one clause to another based on historical use. For example, a CPT cone cross-sectional area should be given in units of square millimetres (mm^2) as used today, and not in square metres (m^2). If there are no special historical reasons for deviating from the units listed below, then the units to be used are:

force	kN
moment	kN·m
density	kg/m^3
unit weight	kN/m^3
stress, pressure, strength and stiffness	kPa
coefficient of permeability	m/s
coefficient of consolidation	m^2/s

4.3 Abbreviated terms

BHA	bottom hole assembly
CCV	consolidated constant volume
CD	consolidated drained
CPT	cone penetration test
CPTU	electrical CPT with measurement of the pore pressures around the cone
CRS	controlled rate of strain
CT	computerized tomography
CU	consolidated undrained
DGPS	differential global positioning system
DS	direct shear