

DIN EN ISO 19901-8



ICS 75.180.10

Entwurf

Einsprüche bis 2022-03-07
Vorgesehen als Ersatz für
DIN EN ISO 19901-8:2015-11

**Erdöl- und Erdgasindustrie –
Spezielle Anforderungen für Offshore-Anlagen –
Teil 8: Meeresbodenuntersuchungen (ISO/DIS 19901-8:2021);
Englische Fassung prEN ISO 19901-8:2021**

Petroleum and natural gas industries –
Specific requirements for offshore structures –
Part 8: Marine soil investigations (ISO/DIS 19901-8:2021);
English version prEN ISO 19901-8:2021

Industries du pétrole et du gaz naturel –
Exigences spécifiques relatives aux structures en mer –
Partie 8: Investigations des sols en mer (ISO/DIS 19901-8:2021);
Version anglaise prEN ISO 19901-8:2021

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2022-01-07 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfs besonders zu vereinbaren.

Stellungnahmen werden erbeten

- vorzugsweise online im Norm-Entwurfs-Portal von DIN unter www.din.de/go/entwuerfe bzw. für Norm-Entwürfe der DKE auch im Norm-Entwurfs-Portal der DKE unter www.entwuerfe.normenbibliothek.de, sofern dort wiedergegeben;
- oder als Datei per E-Mail an noeg@din.de möglichst in Form einer Tabelle. Die Vorlage dieser Tabelle kann im Internet unter www.din.de/go/stellungnahmen-norm-entwuerfe oder für Stellungnahmen zu Norm-Entwürfen der DKE unter www.dke.de/stellungnahme abgerufen werden;
- oder in Papierform an den DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG), 10772 Berlin oder Am DIN-Platz, Burggrafenstr. 6, 10787 Berlin.

Die Empfänger dieses Norm-Entwurfs werden gebeten, mit ihren Kommentaren jegliche relevanten Patentrechte, die sie kennen, mitzuteilen und unterstützende Dokumentationen zur Verfügung zu stellen.

Gesamtumfang 198 Seiten

DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG)

Nationales Vorwort

Dieses Dokument (prEN ISO 19901-8:2021) wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ erarbeitet, dessen Sekretariat von NEN (Niederlande) gehalten wird.

Das zuständige deutsche Normungsgremium ist der Arbeitskreis NA 109-00-01-07 AK „Offshore Bauwerke — Spiegelausschuss zu ISO/TC 67/SC 7“ im DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG).

Dieses Dokument enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die Englische Fassung von prEN ISO 19901-8:2021.

Der Bedarf für eine Deutsche Fassung wird derzeit beraten.

Für die in diesem Dokument zitierten Dokumente wird im Folgenden auf die entsprechenden deutschen Dokumente hingewiesen:

ISO 9001	siehe	DIN EN ISO 9001
ISO 10012	siehe	DIN EN ISO 10012
ISO 10693	siehe	DIN EN ISO 10693
ISO 13628-1	siehe	DIN EN ISO 13628-1
ISO 14688-1:2017	siehe	DIN EN ISO 14688-1:2020-11
ISO 14688-2:2017	siehe	DIN EN ISO 14688-2:2020-11
ISO 14689-1	siehe	DIN EN ISO 14689-1
ISO 17312	siehe	DIN ISO 17312
ISO 17892-2	siehe	DIN EN ISO 17892-2
ISO 17892-3	siehe	DIN EN ISO 17892-3
ISO 17892-4	siehe	DIN EN ISO 17892-4
ISO 17892-5	siehe	DIN EN ISO 17892-5
ISO 17892-6	siehe	DIN EN ISO 17892-6
ISO 17892-7	siehe	DIN EN ISO 17892-7
ISO 17892-8	siehe	DIN EN ISO 17892-8
ISO 17892-9	siehe	DIN EN ISO 17892-9
ISO 17892-10	siehe	DIN EN ISO 17892-10
ISO 17892-12	siehe	DIN EN ISO 17892-12
ISO 19900	siehe	DIN EN ISO 19900
ISO 19901-4	siehe	DIN EN ISO 19901-4
ISO 19901-6	siehe	DIN EN ISO 19901-6
ISO 19901-10	siehe	DIN EN ISO 19901-10
ISO 19902	siehe	DIN EN ISO 19902
ISO 19903	siehe	DIN EN ISO 19903
ISO 19904-1	siehe	DIN EN ISO 19904-1
ISO 19905-1	siehe	DIN EN ISO 19905-1
ISO 19906	siehe	DIN EN ISO 19906
ISO 22475-1	siehe	DIN EN ISO 22475-1
ISO 22476-1:2012	siehe	DIN EN ISO 22476-1:2013-01
ISO 22476-5:2012	siehe	DIN EN ISO 22476-5:2013-03
ISO 22476-8:2018	siehe	DIN EN ISO 22476-8:2019-03
ISO 29001	siehe	DIN EN ISO 29001

ISO 31000	siehe	DIN ISO 31000
ISO/IEC 17025	siehe	DIN EN ISO/IEC 17025
ISO/TR 19905-2	siehe	DIN CEN ISO/TR 19905-2 (DIN SPEC 67998)

Aktuelle Informationen zu diesem Dokument können über die Internetseiten von DIN (www.din.de) durch eine Suche nach der Dokumentennummer aufgerufen werden.

Änderungen

Gegenüber DIN EN ISO 19901-8:2015-11 wurden folgende Änderungen vorgenommen:

- a) Die Anwendungsklassen für In-situ-Prüfgeräte wurden entfernt und durch eine Bewertung der dokumentierten Kalibrierungsergebnisse und Unsicherheitsanalysen ersetzt;
- b) ein neuer normativer Anhang wurde eingeführt, um die Verfahren für die Kalibrierung und Überprüfung von Kegelpenetrometern zu definieren;
- c) ein neuer informativer Anhang mit einem Beispiel für einen Kalibrierschein für Kegelpenetrometer wurde aufgenommen;
- d) die Anhänge wurden entsprechend dem Haupttext und den ISO-Richtlinien für eine verbesserte Lesbarkeit umstrukturiert;
- e) Verweise auf Projektspezifikationen für technische Details wurden, wo möglich, reduziert und die Rollen und Verantwortlichkeiten wurden weiter geklärt;
- f) Aktualisierung der normativen Verweisungen.

Nationaler Anhang NA (informativ)

Begriffe

Reihenfolge und Inhalt der folgenden Begriffe sind identisch mit denen im Abschnitt Begriffe der englischen Fassung.

3 Begriffe

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe.

ISO und IEC stellen terminologische Datenbanken für die Verwendung in der Normung unter den folgenden Adressen bereit:

— ISO Online Browsing Platform: verfügbar unter <https://www.iso.org/obp>

— IEC Electropedia: verfügbar unter <http://www.electropedia.org/>

3.1 Genauigkeit
Grad der Übereinstimmung zwischen einem gemessenen Größenwert und einem wahren Größenwert der Messgröße

3.2 geophysikalische Vermessung des Bohrlochs
Messung physikalischer Eigenschaften eines Bohrlochs und/oder des umgebenden Bodens mit einer oder mehreren in das Bohrloch eingebrachten Messsonden

3.3 Auftraggeber
Partei oder Person, die für die Erkundung des Meeresbodens einschließlich der Erarbeitung der Vorhabensspezifikationen die Gesamtverantwortung trägt

3.4 Koordinatenreferenzsystem
Koordinatensystem, das durch ein Datum auf ein Objekt bezogen ist

Anmerkung 1 zum Begriff: Geodätische und vertikale Daten werden als Referenzrahmen bezeichnet.

Anmerkung 2 zum Begriff: Das Objekt für geodätische und vertikale Referenzrahmen ist die Erde. In planetarischen Anwendungen können geodätische und vertikale Referenzrahmen auf andere Himmelskörper angewendet werden.

3.5 Auftragnehmer
Partei oder Person, die für einen festgelegten Umfang der in den Vorhabensspezifikationen beschriebenen Arbeiten die Verantwortung trägt

3.6 abgeleiteter Wert
Wert für einen geotechnischen Parameter, der aus Prüfergebnissen durch theoretische Überlegungen, durch Korrelationen oder durch Wissen aus gesammelten Erfahrungen ermittelt wird

3.7

Auslegungswert

für die Anwendung bei der Auslegung aus dem repräsentativen Wert abgeleiteter Wert

[QUELLE: ISO 19900:2019, 3.14]

3.8

gestörte Probe

Probe, deren Bodenstruktur, Wassergehalt und/oder Bestandteile aufgrund von Probenahme und Handhabung verändert wurden

3.9

dränierte Bedingungen

Bedingungen, bei denen aufgebrachte Spannungen und Spannungsänderungen vom Bodenskelett so aufgenommen werden, dass keine Veränderung des Porendrucks verursacht wird

3.10

Bohrspülung

Bohrflüssigkeit

Spülflüssigkeit

Flüssigkeit, die zur Unterstützung des Bohrprozesses in ein im Rotary Bohrverfahren erzeugtes Bohrloch gepumpt wird

Anmerkung 1 zum Begriff: Die Hardwarekomponenten, die beim Umgang mit Bohrflüssigkeiten angewendet werden, enthalten in ihrer Benennung meist das Wort „Spül[ung]“ (en: mud) (z. B. Spülungstank, Spülpumpe, Spülventil). Gleiches gilt für Bohrparameter im Zusammenhang mit Bohrflüssigkeiten (Spülungsdruck, Spülungsumlauf usw.).

3.11

Geogefahr

geologische Bedingung, die nachteilige Auswirkungen auf Personen, den Betrieb, die Infrastruktur oder die Umwelt haben kann

3.12

Bodenmodell

2- oder 3- dimensionale Darstellung des Meeresbodens (Bathymetrie) und, sofern zutreffend, der Gegebenheiten des Meeresgrunds zu einem bestimmten Zeitpunkt, die für die betrachtete(n) Offshore Anlage(n) spezifisch ist

3.13

Feldvergleich

en Ground Truthing

Integration von geophysikalischen Daten des Meeresbodens oder des Meeresgrunds mit Daten aus der Meeresbodenuntersuchung und anderen Daten

3.14

Vermessung im Bohrloch

geophysikalische Vermessung des Bohrlochs in einem Abschnitt des Bohrlochs oder des Bohrgestänges, die zwischen dem Messgerät und der Wand des Bohrlochs durchgeführt wird

Anmerkung 1 zum Begriff: Die Anzahl der Parameter, für die eine Messung unter diesen Umständen sinnvoll ist, ist begrenzt.

3.15

intakte Probe

Probe, die mit dem Ziel gesammelt wurde, die in situ vorhandenen Kennwerte der Probe beizubehalten

Anmerkung 1 zum Begriff: Der Begriff kann als Äquivalent zu „ungestörte Probe“ verwendet werden, die in anderen ISO-Dokumenten verwendet wird.

3.16

integrierte Geowissenschaftsstudie

Kombination von geophysikalischen Daten, einem Modell für geologische Prozesse und geotechnische Daten zur Entwicklung eines Bodenmodells

3.17

meeresgeophysikalische Untersuchung

Art der Untersuchung von Lokationen (Bohrstellen) auf dem Meeresboden oder Meeresgrund mittels zerstörungsfreier Verfahren, die das Ausbringen geophysikalischer Geräte ins Meer erfordern

Anmerkung 1 zum Begriff: Siehe Bild 1 in der Einleitung.

3.18

Erkundung von Lokationen im Meer

Erkundung von Bohrstellen im Meer

Art von Untersuchungen an Offshore oder Nearshore Lokationen

BEISPIEL Meeresbodenuntersuchungen, geophysikalische Untersuchungen, Umgebungsuntersuchungen, Metocean Untersuchungen. Siehe Bild 1 in der Einleitung.

3.19

Meeresbodenuntersuchung

Art der Erkundung von Lokationen im Meer mit dem primären Ziel, zuverlässige und repräsentative Daten zur Charakterisierung der Bodenbedingungen am Meeresgrund zur Unterstützung der Auslegung von Offshore Anlagen und/oder für die Bewertung von Geogefahren zu ermitteln

Anmerkung 1 zum Begriff: Siehe Bild 1 in der Einleitung und ISO 19901-10.

3.20

Messwert gemessener Wert

Wert, der bei einer Prüfung gemessen wird

3.21

Bohrlochvermessung im offenen Bohrloch

Vermessung in einem Abschnitt des Bohrlochs ohne beispielsweise Futterrohr oder Bohrgestänge, die zwischen dem Messgerät und der Wand des Bohrlochs durchgeführt wird

3.22

Vorhabensspezifikation

Projektspezifikation

Umfang der Arbeiten für Untersuchungen des Meeresbodens, mit denen ein Auftraggeber einen Auftragnehmer beauftragt hat

3.23

Güteklasse

Klassifizierung der Qualität der ungestörten Probe für den OCR (Überkonsolidationsgrad) von Böden mit geringem bis mittlerem Tonanteil, wobei die Qualität der ungestörten Probe auf der bei Konsolidierungsversuchen im Laboratorium gemessenen Volumenänderung basiert

Anmerkung 1 zum Begriff: Exakte Definitionen der verschiedenen Güteklassen für Proben sind in 10.6, Tabelle 10, angegeben.

Anmerkung 2 zum Begriff: Die Definition der in diesem Dokument angegebenen „Güteklasse“ unterscheidet sich von der Definition der in ISO 22475-1:2006, Tabelle 1 angegebenen „Güteklasse“.

3.24

Vorbohrloch

Rattenloch

Kellyloch

die am Ende des Bohrlochs (über den letzten interessierenden Bereich hinaus) gebohrte zusätzliche Tiefe, die sicherstellt, dass eine vollständige Auswertung des zur geophysikalischen Vermessung des Bohrlochs interessierenden Bereichs durchführbar ist

Anmerkung 1 zum Begriff: Durch das Vorbohrloch können die am Vermessungsstrang weiter oben angebrachten Instrumente den tiefsten interessierenden Bereich erreichen und vermessen.

3.25

aufgearbeiteter Probekörper

Labor Probekörper, der durch Mischen einer Bodenprobe bis zu einem festgelegten Zustand in einem festgelegten Verfahren hergestellt wird

3.26

aufgearbeitete (durchwalkte) Probe

aufgearbeiteter (durchwalkter) Probekörper

Laborprobekörper, der mechanisch unter Beibehaltung eines konstanten Wasseranteils vollständig aufgearbeitet wird

3.27

aufgearbeitete Scherfestigkeit

Scherfestigkeit des aufbereiteten Bodens

3.28

repräsentativer Wert

einer Grundvariablen in einer Bemessungssituation zugeordneter Wert zum Nachweis eines Grenzzustandes

[QUELLE: ISO 19900:2019, 3.40]

3.29

Restscherfestigkeit

Scherfestigkeit bei starker Dehnung, wobei sich das Verhältnis von Scherspannung und Dehnung bei einem konstanten Wert stabilisiert

3.30

Probe

Teil vom Boden oder Gestein, der mit Hilfe bestimmter Probenahmetechniken aus dem am Meeresgrund aufgenommenen Boden gewonnen wird

3.31

Meeresgrund

Materialien unter dem Meeresboden

Anmerkung 1 zum Begriff: Als gleichwertiger Begriff kann im Englischen auch „sub-seafloor“ verwendet werden.

3.32

Meeresboden

Grenzfläche zwischen Meer und Meeresgrund

3.33

Absacken

dauerhafte Abwärtsbewegung einer Plattform aufgrund ihres eigenen Gewichts und aufgrund anderer Einwirkungen

3.34

Lokation Bohrstelle

festgelegter Untersuchungsbereich

3.35

(geotechnischer) Bodenparameter

Bodeneigenschaft, die durch einen Kennwert oder einen Wert quantitativ bestimmt werden kann

Anmerkung 1 zum Begriff: Die Benennung „geotechnisch“ beinhaltet sowohl Boden als auch Gestein.

Anmerkung 2 zum Begriff: Spitzenwiderstand und Kohäsion des undränierten Bodens sind Beispiele für Bodenparameter; eine geringe Festigkeit und eine sehr hohe Dichte sind Beispiele für Kennwerte, die für einen Bodenparameter bestimmt werden können.

3.36

Probekörper

Probemuster

Teil einer Probe, an dem eine Prüfung im Laboratorium durchgeführt wird

3.37

Indexversuch zur Bestimmung der Festigkeit

Prüfung, die einen Hinweis auf die Scherfestigkeit liefert

3.38

Schwellen

Quellen

Ausdehnung aufgrund einer Verringerung der wirksamen Spannung, die entweder auf der Verringerung der gesamten Spannung oder (im Allgemeinen) auf der Absorption von Wasser bei konstanter gesamter Spannung beruht

Anmerkung 1 zum Begriff: Das Schwellen schließt die Umkehr sowohl der Zusammendrückung als auch der Konsolidation ein.

Anmerkung 2 zum Begriff: Ein signifikantes Schwellen der Proben kann durch Entmischung von gelöstem Gas infolge einer Spannungsentlastung bei der Probenahme hervorgerufen werden.

3.39

Unsicherheit

Parameter, der die Streuung der Größenwerte charakterisiert, die einer Messgröße basierend auf den verwendeten Informationen zugeordnet werden

3.40

ungestörte Probe

Probe, bei der keine nennenswerte Veränderung in den Bodeneigenschaften aufgetreten ist

3.41

undrÄnierte Bedingung

Bedingung, bei der aufgebrachte Spannungen und SpannungsÄnderungen sowohl vom Bodenskelett als auch von der Porenflüssigkeit so aufgenommen werden, dass keine VolumenÄnderung hervorgerufen wird

3.42

Kohäsion des undrÄnierten Bodens

maximale Scherspannung beim Fließen des Werkstoffs oder bei einer festgelegten maximalen Dehnung unter undrÄnierten Bedingungen

Anmerkung 1 zum Begriff: Unter Fließen wird der Zustand eines Werkstoffs verstanden, bei dem eine merkliche bleibende Dehnung ohne oder bei einer nur geringen Zunahme der Spannung auftritt.

Anmerkung 2 zum Begriff: Eine Entfestigung ist ebenfalls zu beachten.

4 Symbole, Einheiten und Abkürzungen

4.4 Symbole

a	Netto-Flächenverhältnis eines Konuspenetrometers
C_s	Schwellbeiwert (für Konsolidierungsversuche)
C_v	Konsolidierungsbeiwert
f_s	Reibung der Hülse
$G_{\max}$	Anfangsschermodul (bei kleiner Dehnung)
G_s	relative Dichte von Feststoffen
H_{sf}	Höhe des Bezugspunkts über dem Meeresboden
I	Neigung
I_L	Liquiditätszahl
I_p	Plastizitätszahl
K_0	Erddruckbeiwert im Ruhezustand ($= \sigma'_{h0}/\sigma'_{v0}$)
m_v	Koeffizient der VolumenÄnderung
p'_0	wirksame Vertikalspannung in situ ($= \sigma'_{v0}$)
q_c	Spitzenwiderstand
q_t	Spitzenwiderstand, korrigiert um den Porenwasserdruck
S	Dicke der Flügelsonde
S_t	Bodenempfindlichkeit

$s_u = c_u$	Kohäsion des undränierten (ungestörten) Bodens
s_{uC}	statische Kohäsion des undränierten Bodens beim triaxialen Druckversuch
s_{uD}	statische Kohäsion des undränierten Bodens beim Einfachscherversuch (DSS)
s_{uE}	statische Kohäsion des undränierten Bodens beim triaxialer Extensionsversuch
s_{ufv}	Scherfestigkeit aus dem Flügelscherversuch
$s_{ufv,rem}$	gestörte Scherfestigkeit aus dem Flügelscherversuch
$s_{ufv,res}$	Restscherfestigkeit aus dem Flügelscherversuch
u_2	Porendruck, gemessen durch ein Filter im zylindrischen Teil unmittelbar oberhalb des kegelförmigen Teils des Kegels
v_p	Kompressionswellengeschwindigkeit
v_s	Scherwellengeschwindigkeit
v_{vh}	Geschwindigkeit horizontaler (h), polarisierter Scherwellen mit vertikaler Ausbreitung (v)
Z	Nullwerte der In-situ-Sonde in der Höhe über dem Meeresboden für die Betriebsart Bohren
γ'	Einheitsgewicht des Bodens unter Wasser
N	Poissonsche Zahl
Σ	Spannung
σ'_{v0}	wirksame Vertikalspannung in situ ($= p_0'$)
σ'_{h0}	wirksame Horizontalspannung in situ
σ'_p	Vorkonsolidationsspannung
$\Delta\sigma'_v$	Änderung der wirksamen senkrechten Spannung
ϕ'	wirksamer innerer Reibungswinkel

4.2 Einheiten

Die Einheiten können sich unter Berücksichtigung des früher üblichen Gebrauchs in den einzelnen Abschnitten unterscheiden. Beispielsweise wurde die Querschnittsfläche eines CPT-Konus in der Einheit Quadratzentimeter (cm²) und nicht in Quadratmeter (m²) angegeben. Wenn keine besonderen historischen Gründe für eine Abweichung von den nachfolgend aufgeführten Einheiten vorliegen, dann gelten die folgenden Einheiten:

Kraft	kN
Moment	kN·m
Dichte	kN/m ³
Einheitsgewicht	kN/m ³
Spannung, Druck, Festigkeit und Steifigkeit	kPa
Durchlässigkeitsbeiwert	m/s
Konsolidierungsbeiwert	m ² /s

4.3 Abkürzungen

BHA	Bestückung der Bohrlochsohle (en: bottom hole assembly)
CCV	konsolidiertes konstantes Volumen (en: consolidated constant volume)
CD	konsolidiert entwässert (en: consolidated drained)
CPT	Drucksondierung (en: cone penetration test)
CPTU	Drucksondierung mit Porendruckmessung (en: cone penetration test with pore pressure measurement)
CRS	kontrollierte Dehngeschwindigkeit (en: controlled rate of strain)
CT	Computertomographie (en: computed tomography)
CU	konsolidiert undrained (en: consolidated undrained)
DS	direkter Scherversuch (en: direct shear)
DSS	Einfachscherversuch (en: direct simple shear)
ERP	Notmaßnahmen-Plan (en: emergency response plan)
FVT	Feld-Flügelscherversuch (en: field vane test)
GIS	geographisches Informationssystem (en: geographical information system)
GNSS	globales Satellitennavigationssystem (en: global navigation satellite system)

HAZID	Gefahrermittlung (en: hazard identification)
HAZOP	Gefahren und Betriebsfähigkeit (en: hazard and operability)
HR	hohe Auflösung (en: high resolution)
HSE	Gesundheit, Sicherheit und Umwelt (en: health, safety and environment)
HSEMS	Managementsystem für Gesundheit, Sicherheit und Umwelt (en: health, safety and environment management system)
HVAC	Heizung, Lüftung und Klimatisierung (en: heating, ventilation and air conditioning)
ID	Identifizierung (en: identification)
IL	inkrementelle (schrittweise) Belastung (en: incremental loading)
ISPS	International Ship and Port Facility Security
JSA	Arbeitssicherheitsanalyse (en: job safety analysis)
LAT	niedrigste astronomische Tide (en: lowest astronomical tide)
MARPOL	Internationales Übereinkommen zur Verhütung der Meeresverschmutzung durch Schiffe (en: International Convention for the Prevention of Pollution from Ships)
MBPT	Drucksondierung mit Miniaturkugel (en: miniature ball penetration test)
MCPT	Drucksondierung mit Miniaturkonus (en: miniature cone penetration test)
MSCL	multisensorische Kernaufzeichnung (en: multi-sensor core logging)
MSL	mittlerer Meeresspiegel; Normalnull (en: mean sea level)
MTPT	Drucksondierung mit Miniatur-T-Stange (en: miniature-penetration test)
NPR	Nadelpenetrationsfestigkeit (en: needle penetration resistance)
OC	überkonsolidiert (over-consolidated)
OCR	Überkonsolidationsgrad (en: over-consolidation ratio)
PEP	Projektabwicklungsplan (en: project execution plan)
PPE	persönliche Schutzausrüstung (en: personal protective equipment)
QA	Qualitätssicherung (en: quality assurance)
QC	Qualitätskontrolle (en: quality control)
QP	Qualitätsmanagementplan (en: quality plan)
PPDT	Porenwasserdruck-Dissipationsversuch (en: pore pressure dissipation test)
ROP	Bohrfortschritt (en: rate of penetration)

ROV	Fahrzeug mit Fernbedienung (en: remotely operated vehicle)
RS	Kreisringscherversuch (en: ring shear)
SCPT	Seismische Drucksondierung (en: seismic cone penetration test)
SEM	Rasterelektronenmikroskopie (en: scanning electron microscopy)
SHANSEP	Bestimmung des zeitlichen Verlaufs der Spannungen und normierter Bodenkenngrößen (en: stress history and normalized soil engineering parameters)
SIMOPS	gleichzeitig ablaufende Arbeitsgänge (en: simultaneous operations)
SOLAS	Schutz des menschlichen Lebens auf See (en: safety of life at sea)
SOW	Arbeitsumfang (en: scope of work)
SPT	Standard Penetration Test
SRB	sulfatreduzierende Bakterien (en: sulphate-reducing bacteria)
SWL	sichere Arbeitslast (en: safe working load)
TC	triaxialer Druckversuch (en: triaxial compression)
TE	triaxialer Extensionsversuch (en: triaxial extension)
TOC	gesamter organischer (Kohlenstoff-)Anteil (en: total organic content)
UCT	Druckversuch mit unbehinderter Querdehnung (en: unconfined compression test)
USBL	Ultra Short Baseline (Unterwassernavigationssystem mit ultrakurzer Basislinie) (en: ultra-short baseline)
UHR	ultrahochauflösend (en: ultra-high resolution)
UU	unkonsolidiert, undrained (en: unconsolidated-undrained)
UXO	Blindgänger (en: unexploded ordnance)
VSP	vertikale seismische Profilierung (en: vertical seismic profiling)
WGS	geodätisches Weltsystem (en: world geodetic system)
YSR	Streckspannungsverhältnis (en: yield stress ratio)

Nationaler Anhang NB (informativ)

Literaturhinweise

DIN CEN ISO/TR 19905-2 (DIN SPEC 67998), *Erdöl- und Erdgasindustrie — Offshore Anlagen; Beurteilung von mobilen Offshore Einheiten bezüglich ihres Einsatzgebietes — Teil 2: Hubinseln, Erläuterungen*

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DIN EN ISO 19900, *Erdöl- und Erdgasindustrie — Allgemeine Anforderungen an Offshore-Bauwerke*

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DIN EN ISO 19901-10, *Erdöl- und Erdgasindustrie — Spezielle Anforderungen für Offshore-Anlagen — Teil 10: Meeresgeophysikalische Untersuchungen*

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DIN EN ISO 19906, *Erdöl- und Erdgasindustrie — Offshore-Bauwerke für den Arktis-Bereich*

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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 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, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 7, *Offshore structures*.

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

The main changes compared to the previous edition are as follows:

- application classes for *in situ* testing tools are removed and replaced by an assessment of documented calibration results and uncertainty analyses;
- a new normative annex is introduced to define the procedures for calibration and verification of cone penetrometers;
- a new informative annex is included with an example calibration certificate for cone penetrometers;
- annexes have been restructured according to the main text and ISO guidelines for ease of reading;
- references to project specifications for technical details have been reduced where possible and roles and responsibilities have been further clarified.

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 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 (see ISO 19900). The implications involved in modifications, therefore, need to be considered in relation to the overall reliability of all offshore structural systems.

This document is applicable for marine soil investigation, which 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.

This document 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 parameter values.

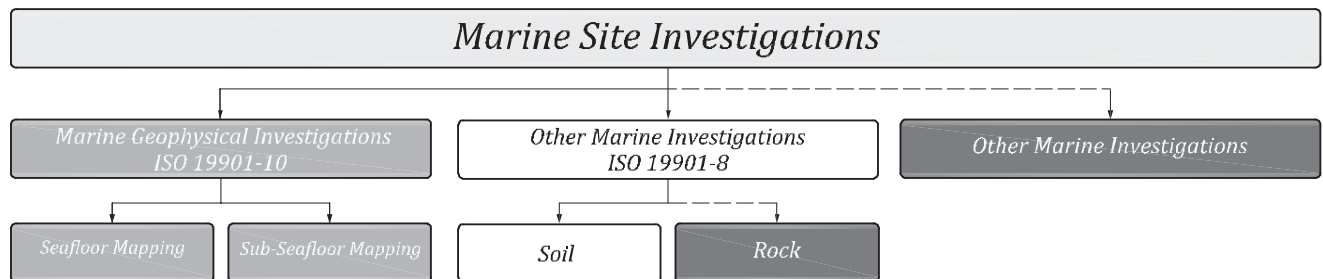


Figure 1 — Marine soil investigations shown as one of many types of marine site investigations

This document 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 document is based on the assumptions that:

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

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 ISO documents, 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 document includes both informative and normative annexes. Annex A is an informative annex, which gives additional information intended to assist the understanding or use of this document. The clause number in Annex A is the same as in the normative main text to facilitate cross-referencing. Annex B is a normative annex, which presents methods for calibration and verification of cone penetrometers. Annex C is an informative annex, which presents an example report from the calibration and measurement of cone penetrometer sensors. Annex D is an informative annex, which covers conduct of laboratory tests as part of marine soil investigations.

Petroleum and natural gas industries — Specific requirements for 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.

Soil type references throughout this document follow the ISO 14688-1:2017 and ISO 14688-2:2017 definitions. Rock materials are only covered by this document to the extent that 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 document.

NOTE 1 Clause D.13 provides guidance.

Foundation design is not covered by this document.

NOTE 2 ISO 19901-4 and the respective design standards for the specific types of offshore structures as listed in the Foreword cover foundation design.

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

This document provides requirements and guidance for obtaining measured values and derived values. This document excludes requirements and guidance for determination of design and representative values.

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, 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*

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

ISO 14688-1:2017, Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description

ISO 14688-2:2017, Geotechnical investigation and testing — Identification and classification of soil — Part 2: Principles for a classification

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

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

accuracy

closeness of agreement between a measured quantity value and a true quantity value of a measurand

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.

Note 2 to entry: For geodetic and vertical reference frames, the object will be the Earth. In planetary applications, geodetic and vertical reference frames may be applied to other celestial bodies.

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 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, infrastructure 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 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.

3.15

intact sample

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

Note 1 to entry: Term can be taken as equivalent to undisturbed sample used in other ISO documents.

3.16

integrated geoscience study

combination of geophysical data, a model for geological processes and geotechnical data for development of a ground model

3.17

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 in Introduction.

3.18

marine site investigation

type of investigation at an offshore or nearshore site

EXAMPLES Marine soil investigation, geophysical investigation, environmental investigation, metocean investigation. See Figure 1 in Introduction.

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 and ISO 19901-10.

3.20

measured value

value that is measured in a test

3.21

open-hole logging

borehole geophysical logging in a section of the borehole without, for example, casing or drill pipe between the tool and the borehole wall

3.22

project specification

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

3.23

quality class

classification of undisturbed sample quality for low to medium OCR clays, where the undisturbed 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 10.6, Table 10.

Note 2 to entry: The definition of 'quality class' given in this document differs from the definition of 'quality class' given in ISO 22475-1:2006, Table 1.

3.24

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 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.

3.25

reconstituted specimen

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

3.26

remoulded sample

remoulded specimen

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

3.27

remoulded shear strength

shear strength of remoulded soil

3.28

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]

3.29

residual shear strength

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

3.30

sample

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

3.31

seabed

materials below the seafloor

Note 1 to entry: Sub-seafloor can also be used as an equivalent term.

3.32

seafloor

interface between the sea and the seabed

3.33

settlement

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

3.34

site

defined investigation area

3.35

soil [geotechnical] parameter

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

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

Note 2 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.

3.36

specimen

part of a sample used for a laboratory test

3.37

strength index test

test that yields an indication of the shear strength

3.38

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.

3.39

uncertainty

parameter that characterizes the dispersion of the quantity values that are being attributed to a measurand, based on the information used

3.40

undisturbed sample

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

3.41

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

3.42

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_s	swelling index (for consolidation tests)
C_v	coefficient of consolidation
f_s	sleeve friction
$G_{\max}$	initial (small strain) shear modulus
G_s	specific gravity of solid particles
H_{sf}	height of reference point above seafloor
I	inclination
I_L	liquidity index
I_P	plasticity index
K_0	coefficient of earth pressure at rest ($= \sigma'_{h0} / \sigma'_{v0}$)
m_v	coefficient of compressibility
p_0'	<i>in situ</i> vertical effective stress ($= \sigma'_{v0}$)
q_c	cone resistance
q_t	cone resistance corrected for pore water pressure effects
S	vane blade thickness
S_t	soil sensitivity
$s_u = c_u$	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
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
Z	height above seafloor for drilling mode <i>in situ</i> probe zero reference readings
γ'	submerged unit weight of soil
N	Poisson's ratio
Σ	stress
σ'_{v0}	<i>in situ</i> vertical effective stress ($= p_0'$)
σ'_{h0}	<i>in situ</i> 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 can vary from one clause to another based on historical use. For example, a CPT cone cross-sectional area used to be given in units of square centimetres (cm²), and not in square metres (m²). If there are no special historical reasons for deviating from the units listed below, then the following units apply:

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	cone penetration test with pore pressure measurement
CRS	controlled rate of strain
CT	computed tomography
CU	consolidated undrained
DS	direct shear
DSS	direct simple shear
ERP	emergency response plan
FVT	field vane test
GIS	geographical information system
GNSS	global navigation satellite system
HAZID	hazard identification
HAZOP	hazard and operability
HR	high resolution
HSE	health, safety and environment
HSEMS	health, safety and environment management system
HVAC	heating, ventilation and air conditioning
ID	identification
IL	incremental loading
ISPS	international ship and port facility security
JSA	job safety analysis
LAT	lowest astronomical tide
MARPOL	international convention for the prevention of pollution from ships
MBPT	miniature ball penetration test
MCPT	miniature cone penetration test
MSCL	multi-sensor core logging
MSL	mean sea level
MTPT	miniature T-bar penetration test
NPR	needle penetration resistance
OC	over-consolidated
OCR	over-consolidation ratio
PEP	project execution plan
PPE	personal protective equipment
QA	quality assurance
QC	quality control
QP	quality plan

PPDT	pore pressure dissipation test
ROP	rate of penetration
ROV	remotely operated vehicle
RS	ring shear
SCPT	seismic cone penetration test
SEM	scanning electron microscopy
SHANSEP	stress history and normalized soil engineering parameters
SIMOPS	simultaneous operations
SOLAS	safety of life at sea
SOW	scope of work
SPT	standard penetration test
SRB	sulphate-reducing bacteria
SWL	safe working load
TC	triaxial compression
TE	triaxial extension
TOC	total organic content
UCT	unconfined compression test
USBL	ultra-short baseline
UHR	ultra-high resolution
UU	unconsolidated-undrained
UXO	unexploded ordnance
VSP	vertical seismic profiling
WGS	world geodetic system
YSR	yield stress ratio

5 Objectives, planning and requirements

5.1 Objectives

The objectives of marine site investigations are to make relevant and adequate data available at the various project phases. In particular, the acquired data are usually required to enable assessment of the site suitability with respect to the offshore structure and the level of risks for the foundation and integrity of that structure.

NOTE ISO 31000 provides guidance on risk management principles.

The general objectives of a marine soil investigation are to establish the characteristics and mechanical properties of the seabed by acquisition, evaluation and presentation of geotechnical information derived from methods relying on tools penetrating into the seabed.

5.2 Planning

5.2.1 Sequence of activities

Marine site investigations commonly consist of the following activities, often performed in the sequence listed below and illustrated in Figure 2:

- desk study, including the evaluation of information available in the public domain, available geophysical data, and the results of any previous marine soil investigations in the area;
- marine geophysical investigations (guidance provided in ISO 19901-10);
- marine soil investigations, which can comprise one or more phases to suit the project needs;
- further integrated geoscience study combining the information gathered in the desk study, marine geophysical investigation and marine soil investigation phases.

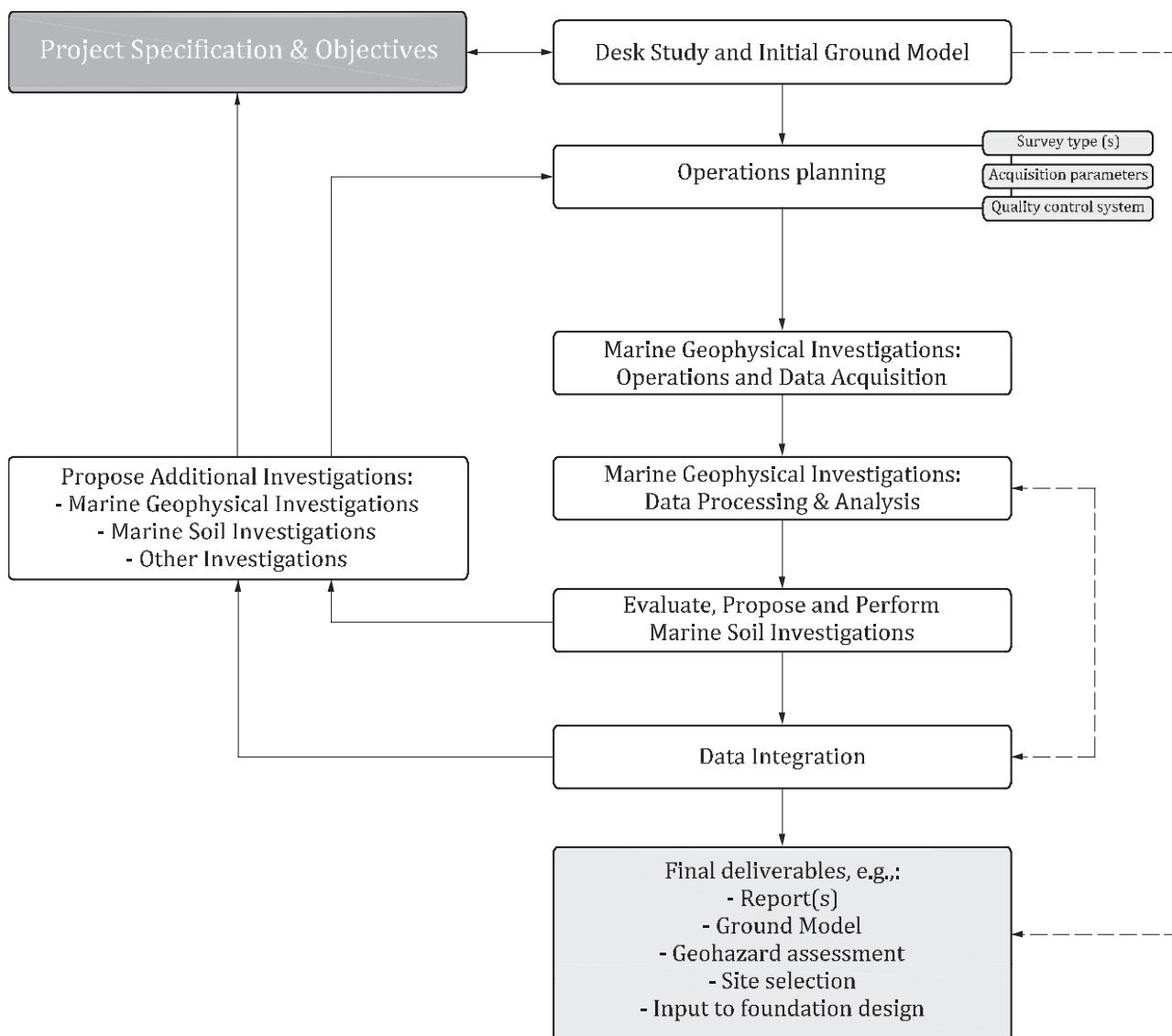


Figure 2 — Typical sequence of activities in marine site investigations

Marine geophysical investigations typically comprise:

- bathymetry and seafloor topography, using a multi-beam echosounder;
- seafloor features and obstructions, using methods such as side scan sonar imaging and magnetometer surveys;
- seabed stratigraphy, using methods such as sub-bottom profiling and ultra-high-resolution seismic reflection.

A marine geophysical investigation typically covers a large extent of seabed, enabling the identification of localized, non-characteristic seabed features, such as the following:

- buried channel, boulders, or ice gouge features;
- erosion features;
- slides or shallow mass transport deposits;
- gas, gas pockets or potential gas pockets;
- specific seafloor features (e.g. pockmarks, boulders, concretions, chemo-synthetic communities and seafloor expulsion features, drill cuttings mounds);
- manmade hazards, such as UXO.

A 'limited-scope' marine soil investigation is commonly performed in conjunction with marine geophysical investigations for the purpose of preliminary ground truthing. The results of a marine geophysical investigation, alone or in addition to a desk study, are generally not sufficient for detailed design of an offshore structure.

A marine soil investigation can include logging, *in situ* testing and sampling operations, with field and onshore laboratory testing performed on any recovered samples, evaluation of geotechnical data and results and reporting. Specific guidance is given on selection of appropriate equipment and procedures in subsequent clauses of this document. The date by which appropriate geotechnical information is required determines when a marine soil investigation should be done. Having the marine soil investigation on the critical path can adversely impact subsequent activities, particularly in case of unexpected findings that require additional work.

Considerations for planning marine site investigations include project phases, requirements of the offshore structure and risk level.

NOTE 1 Examples of project phases are site selection, conceptual design, preliminary design, detailed design, re-certification and decommissioning. Risk level is commonly expressed by probability of failure and consequences of failure. Design codes commonly rely on implicit or explicit risk levels.

NOTE 2 Guidelines concerning the planning and scoping of site investigations for multi-facility sites can be found in SUT (2021) ^[108].

Geotechnical design requirements for the offshore structure shall be established according to ISO 19900. The geotechnical design requirements depend on several factors that can influence the planning of the scope and extent (spatial area and explored depth) of the marine site investigations, in particular the following:

- project phase, ranging from concept selection to decommissioning;
- type of offshore structure and foundation solutions;
- types and magnitudes of actions (loadings);
- related design situations, such as bearing capacity, stability, settlements/displacements, soil-structure interaction, installation/removal aspects;
- criticality of design situations and the possible need for optimization of design and related geotechnical parameter values;
- methods to be adopted for solving/analysing the various design situations;

— geohazards.

5.2.2 Integrated geoscience studies

Most projects will benefit from performing integrated marine site investigations, especially in view of the need to develop soil parameters for designing the foundations of planned offshore structures.

The principles of a ground model and an integrated geoscience study are given in ISO 19901-10. A multi-disciplinary team with close cooperation of geologists, geophysicists, geotechnical specialists and facility designers, involving both the marine site investigation contractor(s) and the site owner/operator, is essential for an integrated study.

The integrated study starts with an initial ground model based on the desk study. The initial ground model can be updated by marine geophysical investigation, which is used to interpret general stratigraphy and define the scope of the marine soil investigation. Such an integrated approach allows for a comprehensive definition of the final ground model and identification of potential geohazards in the top 100 m to 200 m of soil below the seafloor.

Experienced geotechnical and geophysical practitioners shall be involved in the data integration and development of a ground model. The integration of multiple data sets should consider the following:

- a) good communication and interaction in the multi-disciplinary team conducting an integrated study are essential, so that the practical limitations and uncertainties related to each set of marine geophysical and marine soil investigation data or methods are properly understood;
- b) the derivation of quantitative soil properties using marine geophysical investigation data is a fairly novel and challenging exercise with inherent uncertainties that should be assessed consistently by integrated teams including geologists, geophysicists, geotechnical specialists and data science specialists.

5.3 Scope of work and development of project specifications

The scope of work and extent of a marine soil investigation shall be given in the project specifications, including any planning activities to be undertaken by the contractor.

The project specifications should state the objectives of the marine soil investigation.

The project specifications should, if relevant, include foundation details of the offshore structures and the selected design approaches.

The project specifications shall assign who is responsible for particular activities (i.e. client or contractor) and shall define the particular activities and corresponding methods to be adopted. Where relevant, the project specifications should refer to methods described in this document. Any references to alternative methods should be accompanied by method-specific information as applicable.

For a given scope of work, if methods are not defined in the project specifications, the methods given in this document shall be followed, and if not defined herein, then the contractor's normal practice applies. The project specifications may refer to or describe alternative methods not covered by this document.

The order of precedence for application of requirements for the execution of work shall be:

- 1) the project specifications;
- 2) requirements of document for the given scope of work;
- 3) contractor's normal practice.

NOTE 1 Requirements set by regional, national, and local regulations and standards will take precedence and can be different from those given in this document.

NOTE 2 A project can have more than one project specification.

NOTE 3 The project specifications can be updated during the course of a project when the client and contractor agree to deviate from the original project specifications.

Regarding marine operations, project specifications shall define responsibility for clarifying site clearance issues and any required mitigation measures. Site access or clearance issues typically include:

- navigation requirements such as minimum stand-off distance from existing facilities;
- water depth, seafloor slope and unevenness;
- possibility of encountering shallow gas, unexploded ordnance and contaminated ground;
- site permits, including protected habitat and sample export.

Where the client holds site access or clearance related information, this shall be made available to the contractor.

The project specifications shall, where applicable, include requirements for:

- a) vessel positioning and equipment positioning methods and accuracy;
- b) determination of the extent of logging, sampling and testing, consisting of:
 - 1) type, number, location and depth of borehole geophysical logging (see Clause 7);
 - 2) type, number, location and depth of *in situ* testing locations (see Clause 8);
 - 3) type, number, distribution, location and depth of sampling locations (see Clause 9);
 - 4) type and number of offshore and onshore laboratory tests (see Clause 10);
- c) choice of appropriate vessel, equipment and techniques (see Clauses 5 to 10);
- d) reporting, including presentation of the results of the marine soil investigation, development of a ground model and any associated data interpretation (see Clause 11).

In situ testing data should be reported to the client after the execution of each test, and prior to execution of subsequent tests, for verification purposes. Preliminary results should be reviewed with the client in order to implement any changes to the survey programme before the end of the fieldwork.

Laboratory testing shall be performed in accordance with the project specifications. If not defined in the project specifications, an applicable method in ISO documents shall be followed. In the absence of an applicable method in ISO documents, alternative methods, such as those defined in ASTM standards may be followed.

Where it is not possible to define an item in the project specifications at the outset of a marine soil investigation, such as the consolidation stresses to be used in laboratory tests, then the project specifications should define who is responsible for the activity and the approach to be taken.

Default application classes that shall be used, if otherwise not given in project specifications, are given in the relevant clauses of this document.

5.4 Health, safety and environmental requirements for marine operations

5.4.1 General

The marine soil investigation shall conform to the project HSE requirements given in the project specifications. Marine operations shall be conducted in accordance with a project HSE plan. The project HSE plan shall be prepared before start of the project-specific marine operations and can be part of a PEP. Annex A provides guidance about the HSE plan.

5.4.2 Investigation vessel

The vessel shall have an HSEMS. The HSEMS should conform to the requirements of the international management codes for safe operation of ships (ISM code) and for pollution prevention (MARPOL code), and with the SOLAS code, or equivalent codes. The vessel should also conform to the ISPS code, where applicable.

The vessel shall be crewed/staffed with a sufficient number of qualified, trained and experienced persons to perform required marine soil investigation operations, including the operation, maintenance and repair of safety critical equipment.

The safety and well-being of those involved in, and impacted by, the marine soil investigation shall be considered. Persons involved shall be familiar with safety procedures requisite for the safe completion of tasks in which they participate (JSA) and general onboard safety. The operators of marine soil investigation equipment shall have proper training and experience in the use of the equipment. Relevant persons shall be aware of proper reporting requirements for HSE incidents. HSE incidents or accidents shall be reported.

The investigation vessel shall have appropriate safety equipment to conform to SOLAS codes or equivalent codes, including adequate maritime lifesaving equipment, and shall have personal protective equipment (e.g. hard hats, safety glasses, flotation work vests, safety lines) as required by individual JSAs and vessel HSEMS, and shall have onboard personnel familiar with and trained in its use.

Special care should be exercised for ‘specially-mobilized’ vessels, as opposed to purpose-built vessels, for marine soil investigation, to ensure all temporarily-mobilized equipment is safely installed and operated, and that interfaces between permanent vessel crew, who can be unfamiliar with marine soil investigation operations, and temporary crew members (e.g. positioning crew, client representative(s) and any other specialist crew members) are properly managed.

Marine soil investigation equipment shall not be used before it is safely installed. Lifting equipment, such as cranes, booms, hoists, spreader bars, slings, shall be suitable for the proposed use, checked, inspected or certified, and appropriately tagged or marked. During the marine soil investigation, the vessel should be subject to ongoing safety monitoring.

When operations become unsafe for any reason, such as excessive vessel motion, work shall cease and equipment shall be secured.

5.4.3 Hazardous substances and acoustic noise

Substances, such as drilling mud, laboratory chemicals and radioactive sources, can require special care during handling and storage. The presence and special handling and storage requirements of any hazardous material on board the vessel shall be documented, such as in the project HSE plan.

The project HSE plan should consider the potential impact of in-water investigation equipment on the marine environment (e.g. loss of hydraulic fluid, acoustic noise).

5.4.4 Shallow gas

Shallow gas poses a significant hazard to marine operations. Release of shallow gas from the seabed into the sea and atmosphere also has an environmental impact.

A shallow gas hazard assessment shall be undertaken to identify the likelihood of encountering gas during a marine soil investigation for the specific locations, depths below seafloor and planned activities. The shallow gas hazard assessment should typically consider the following:

- a) distance to production infrastructure and historic well-drilling activity;
- b) desk study information, including regional geology, possible presence of gas hydrates and relevant offset well information;
- c) marine geophysical investigation data, considering type, quality, resolution, depth of penetration below seafloor, and timing of the data acquisition;

NOTE 1 There are a number of examples where a shallow gas release took place during a marine soil investigation while it was not identified by a site-specific marine geophysical investigation. Reasons can include the presence of dissolved gas in pore water and the occurrence of thin gas bearing layers. Use of geophysical data alone can result in the inevitable level of uncertainty related to the identification of a shallow gas hazard.

- d) potential for changes since marine geophysical investigation (e.g. due to well-drilling activity);
- e) potential depth, pressure and volume of shallow gas;

NOTE 2 In most cases, no reliable information will be available on potential pressure, volume and formation flow rate of shallow gas.

- f) possible sources of shallow gas and likely gas characteristics (composition, toxicity, flammability, density).

A risk assessment shall be undertaken considering the potential consequences of gas release and the mitigating measures available.

5.5 Other requirements

5.5.1 Operational requirements

The proposed scope of the marine soil investigation shall be considered when selecting vessels and investigation tools along with the environmental conditions at the planned fieldwork site, such as:

- water depth;
- seafloor slope;
- wave and current conditions;
- possibility of shallow gas/hydrates, shallow water flow and other drilling hazards.

Lifting, handling and deployment facilities (e.g. A-frames, booms, davits, cables, cradles, drilling equipment, winches) for the required logging, sampling and *in situ* testing equipment, supplies and other equipment shall be suitable for the purposes required and shall be certified for such use where appropriate. An appropriate inspection regime shall be in place. Dynamic effects from vessel motion and the additional frictional and suction forces imposed on a piece of investigation equipment (e.g. seafloor frame, corer, CPTU) shall be included when determining the maximum anticipated loading on a lifting element, as this additional loading can be significant.

Equipment used during the marine soil investigation should have documentation consisting of operational and maintenance procedures. Where two or more pieces of equipment have a critical interface, those interfaces shall be evaluated to ensure proper operation.

Daily field activities shall be documented during the field operations.

5.5.2 Quality requirements

Experienced geotechnical practitioners shall be involved during the planning and preparation of the marine soil investigation scope and project specifications.

The client should have an appropriate project quality management system in place, with quality control to be exercised consistently and competently in all phases of investigation and evaluation. The contractor should operate a documented quality management system, such as ISO 9001 or ISO 29001.

A project QP should be incorporated as part of a PEP for the marine soil investigation (see Annex A). The QP should detail the organizational responsibilities, activities, and an index of referenced and applicable procedures to complete the scope of the marine soil investigation.

Quality system audits against the quality management system should be performed. The client and contractor should address and resolve audit reports, recommendations and/or corrective actions within the responsibility of the client and contractor respectively.

5.5.3 Specific considerations for unconventional soils

The requirements and recommendations in this document have been developed primarily for use in conventional soils, i.e. siliceous sands and clays of terrigenous origins which have relatively well

understood generic properties, and for which there are well established global marine soil investigation practices. When performing a marine soil investigation in frontier areas, or areas known or suspected to contain unconventional soils, this can require special handling or treatment for soils such as:

- siliceous terrigenous soils (e.g. glacial tills, frozen soils);
- unconventional terrigenous soils (e.g. volcanic ash, silts, glauconitic soils, micaceous soils);
- non-terrigenous soils (e.g. carbonate soils, calcareous soils, siliceous oozes).

The equipment, methods and procedures can also require tailoring to investigate properties that can pose particular difficulties for geohazard assessments and engineering. Examples of soils with specific generic properties that can need special attention are listed in Table A.3.

NOTE Calcareous deposits offer an example of how an investigation can need to be adapted to suit soil type: such soils can be variably cemented and range from lightly cemented with sometimes significant void spaces to extremely well cemented. Therefore, in planning a marine soil investigation, it is important to incorporate sufficient flexibility in the scope of work to switch between soil sampling, rock coring, and *in situ* testing techniques as appropriate. In these soils, a carefully developed field and laboratory testing programme can be warranted. ISO 19901-4 provides relevant guidance.

6 Deployment of investigation equipment

6.1 Non-drilling mode deployment

Non-drilling mode encompasses the practice by which geotechnical testing or sampling tools are initiated at the seafloor and penetrated in a single stroke to refusal depth or to a predetermined depth. Tool penetrations generally vary from 0,5 m to greater than 25 m below seafloor, depending on the tool that is deployed and the geology that is encountered. Penetrations in excess of 40 m are possible using specialist equipment.

A vast array of geotechnical testing and sampling equipment is deployed using this technique. The more sophisticated of these tools are landed on the seafloor prior to the commencement of the seabed penetration, i.e. fixed seafloor reference. The simplest of these tools are simply lowered until they encounter the seafloor, allowed to penetrate to refusal under their own weight, then extracted and recovered to the vessel deck, i.e. no fixed seafloor reference.

The quality of data acquired can vary with the level of sophistication of the tools. Sophisticated seafloor-founded, non-drilling mode rigs can acquire high quality samples or *in situ* data. At the other end of the spectrum, non-heave-compensated winch-controlled tools, such as gravity corers, Kullenberg piston corers and vibro corers, can have a limited capacity to acquire good quality samples.

A common limitation of non-drilling mode equipment relates to the inability to achieve a target penetration depth when a seabed layer is intercepted whose strength exceeds the penetration capability of the tool.

Notwithstanding the above, non-drilling mode tools are widely used for acquiring seabed geotechnical data in favourable geological conditions, due to their generally high level of availability, comparatively lower cost, and their capacity to be deployed from a wide range of vessels.

6.2 Drilling mode deployment

6.2.1 General

In drilling mode, logging, sampling and *in situ* test tools are deployed into the seabed, initially commencing from the seafloor and thereafter from the bottom of a borehole that is progressed via rotary drilling.

Drilling mode operations can be undertaken from the sea surface (referred to as 'vessel drilling'), from seafloor-founded drill rigs (referred to as 'seafloor drilling') and combinations thereof.

Geotechnical tools are deployed to the bottom of the borehole using a variety of techniques, including wireline, free fall, or via advancement and recovery of the drill string itself. Once located at the bottom of the borehole, the geotechnical tool is penetrated via hydraulic or mechanical means until the maximum stroke length, the borehole target depth, or the mechanical capacity of the system is achieved.

At the completion of a testing or sampling interval, the tool is either recovered to the surface through the drill string (vessel drilling), or temporarily stored on the rig (seafloor drilling). The borehole is then progressed to the next testing or sampling depth.

Further provisions related to rotary drilling techniques are provided in Clause 7.

6.2.2 Vessel drilling

Vessel drilling operations are undertaken from either:

- a spudded, anchored or dynamically positioned floating vessel, such as a drill ship, semi-submersible vessel, barge or similar craft; or
- a stable non-floating platform, such as a jack-up or permanent seabed structure.

Vessel drilling systems are influenced by movements associated with surface environmental conditions. For many vessel drilling systems, the vertical stability of the drill string can be controlled or limited by means of

- a seafloor-founded template with a 'hard-tie system' heave compensator (see Zuidberg et al. (1986)^[190]); or
- a heave compensator on the drilling vessel in conjunction with soil resistance that reduces movement of the drill string.

Less sophisticated vessel drilling systems are uncompensated against vessel heave. Further discussion of the effects of vessel heave on drill string stability, and the accuracy of borehole depth measurements, is provided in A.6.2.

6.2.3 Seafloor drilling

Seafloor drilling systems are either landed on the seafloor and a catenary is formed with the control umbilical, or alternatively a constant tension winch is used to isolate the rig from vessel movements and environmental conditions at the sea surface. All operations are then undertaken via remote control.

The stability of seafloor drilling systems is largely dependent on the capabilities of the footings used to support the rig. Sophisticated footings systems can incorporate the capacity to land on steep slopes, self-level the rig, and monitor the vertical height of the rig relative to the seafloor to enhance the accuracy of borehole depth measurements.

6.3 Accuracy of vertical depth measurements

6.3.1 General

Accurate measurement of vertical depth assists in ensuring that:

- the vertical positions of data points can be referenced to a vertical datum such as seafloor or mean sea level;
- variations in seabed stratigraphy, including seafloor, are accurately defined;
- appropriate overburden and pore water pressure corrections are applied to *in situ* test data;
- adjacent samples and *in situ* test data can be precisely correlated;
- appropriate confining stresses are specified during subsequent laboratory test programmes.

6.3.2 Factors affecting the accuracy of vertical depth measurements

A data point can be defined at any depth below seafloor at which geotechnical data are acquired. The depth accuracy of a data point can vary depending on:

- water depth;
- soil conditions near seafloor;
- metocean conditions at the time of investigation;
- selected investigation tools;
- the mode by which equipment is deployed;
- the vertical stability of the equipment during the data acquisition phase;
- the accuracy to which vertical measurements are able to be made;
- the accuracy to which a sample data point can be estimated within a sampling tool.

EXAMPLE 1 The achievable depth accuracy when using a vessel-mounted drilling system can depend on the prevailing environmental conditions at the sea surface, the associated vessel motions, the water depth, the capability of a vessel's heave-compensation system, and whether the drill string can be stabilized at the seafloor during downhole data acquisition. In contrast, the depth accuracy achieved with a seafloor-founded system can depend on the capabilities of the monitoring system used to estimate the position and levelness of the rig relative to the seafloor, and the length of the drill string or push rods deployed downhole.

Data point depth accuracy can additionally vary as a result of the performance of a sampling tool.

EXAMPLE 2 The allocation of sample loss within a sampling run is often solely based on engineering judgement. This can introduce additional uncertainty as to the actual depth from which the sample originated.

6.3.3 Depth accuracy classes

The project specifications should include the depth accuracy class as listed in Table 1 to be achieved in a marine soil investigation based on the intended use of the geotechnical data, with due consideration of the investigation scope, the capabilities of the equipment under consideration and procedures. Multiple depth accuracy classes can be specified, for example differentiating between data points acquired by *in situ* testing and sampling operations. The depth accuracy for a sample data point depends on the accuracy of the sample position within a sampling tool, i.e. allocation of any sample loss/extension within a sampling run. Guidance is provided in 9.5 and Annex A.

If no depth accuracy classes are given in the project specifications, a default value Z2 shall apply to data points acquired by borehole geophysical logging and *in situ* testing and a default value Z3 shall apply for data points acquired by sampling. If samplers with no fixed seafloor reference are used, the default value Z5 shall apply (see 9.5 and A.6.3.3).

Table 1 — Depth accuracy classes for data points relative to seafloor

Depth accuracy class	Maximum data point depth uncertainty (m)
Z1	0,1
Z2	0,5
Z3	1,0
Z4	2,0
Z5	> 2,0

Documentation demonstrating the depth accuracy that can be achieved with proposed investigation equipment shall be provided by the contractor(s). For cases where depth accuracy is expected to vary with changes in water depth and/or depth of data point below the seafloor, the variation in depth accuracy class should be estimated for each intended investigation area. The achieved depth accuracy class or depth accuracy classes shall be reported. The reporting on depth accuracy class shall include the method and numerical values used for estimation of data point uncertainty. The vertical datum should be seafloor as found immediately before the marine operations at the target location.

6.4 Horizontal positioning

The accuracy to which boreholes and/or equipment are located on the seafloor is an important aspect of a geotechnical data set, because it is imperative that

- current investigation locations are aligned with previous and future marine soil investigations, and the installation of facilities;
- known seafloor hazards, including installed facilities, natural seabed obstructions, excessive gradients, identified areas of shallow gas, UXO and other features, are avoided with confidence.

The coordinate reference system and corrections to be applied to the data set shall be included in the project specifications.

Specification of horizontal positioning tolerances can be influenced by:

- the type of facilities to be installed on the seafloor;
- the type, accuracy capabilities and levels of equipment redundancy of the positioning equipment;
- the proximity of existing facilities, including the estimated accuracy of their actual positions;
- the known seafloor topography: water depth, seafloor slopes, natural features.

Further guidance on horizontal positioning requirements is provided in ISO 19901-10.

6.5 Interaction of investigation equipment with the upper seabed

The action of landing and operation of equipment on the seafloor can disturb the upper seabed from the applied surcharge pressures or lead to the seafloor template penetrating into the upper seabed. This can be detrimental to data quality, particularly for very soft seabed. Where appropriate, consideration should be given to deployment of specific investigation equipment for acquisition of high-quality data for the upper seabed (e.g. equipment with no fixed seafloor reference, equipment with low bearing pressure, and sophisticated seafloor drills with large, extended footings). Detailed bathymetry information is normally required to confirm that the investigation equipment can be safely operated.

Reporting shall include an assessment of the interaction of the deployed investigation equipment with the upper seabed, and whether this can have adversely affected the acquired data. Further guidance is provided in A.6.5.1.

7 Drilling and logging

7.1 General

Drilling operations can be undertaken by various modes of equipment deployment defined within Clause 6.

A borehole is advanced by the combined action of a rotating cutting surface (the drill bit) on material at the bottom of the hole and the flow of drilling fluids that flushes drill cuttings in suspension from the bottom of the hole up the enclosing annulus between the drill pipe and borehole wall (or casing inner wall).

Some soil disturbance ahead of the drill bit is inevitable and can have a measurable effect on data quality. Excessive, or varying, weight on the drill bit tends to increase soil disturbance as the bit impacts virgin material at the drill face; rotation speed and torque can also influence sample quality. Excessive drilling fluid pressure can induce hydraulic fracture or erosion of virgin material. Excessive drilling fluid flow can soften or erode virgin material. Soil disturbance can often be assessed by inspection of the results from the sampling and *in situ* testing and operational methods adjusted as required. The depth of soil disturbance below the drill face, and the magnitude of its effect, tend to be greater for softer soils.

For marine drilling operations, the vertical stability of the drill string during borehole advancement is critical to the recovery of high-quality geotechnical data. Fluctuations in applied bit weight, and associated displacements, during sampling and *in situ* testing operations can be detrimental to data quality. Drill string stability is largely affected by the type of equipment used to deploy the drill string. Further information on this issue is provided in Clause 6.

The efficient delivery of the drilling operation can be fundamental to the overall success of the marine soil investigation.

7.2 Project-specific drilling requirements

The choice of drilling equipment suitable for a particular marine soil investigation is generally dictated by a number of key project-specific drilling requirements, which can consist of the following:

- expected soil conditions and possible drilling hazards, such as shallow gas, flowing sands, swelling clays, hydraulic fracture potential;
- required borehole depth and purpose of geotechnical borehole(s):
 - borehole suitable for deployment of specific testing or sampling tools, and/or
 - performance of a pilot hole or borehole to acquire drilling parameters (i.e. destructive drilling);
- site environment and seafloor characteristics (e.g. water depth, expected weather and sea conditions (current, tide, extremes of temperature), proximity of surface/submerged/seafloor/buried infrastructure, seafloor topography, natural seafloor features);
- allowable uncertainty in borehole depth measurements (see 6.3);
- HSE considerations (e.g. manned interventions on the drill floor, environmental discharge regulations for drill cuttings);
- logistical considerations (e.g. project schedule, availability of equipment).

7.3 Drilling objectives and selection of drilling equipment and procedures

Drilling objectives of the marine soil investigation are typically one or more of the following:

- to recover data of optimal quality, with minimal soil disturbance from drilling, where the marine soil investigation results will be used to determine geotechnical parameters for design purposes;
- to maximize the continuity of data recovered within a borehole (at the possible expense of reduced data quality), for example for geological investigations for which key horizons can be very thin and therefore require a data record as continuous as possible;
- to maximize the speed of drilling, at the expense of data quality and/or continuity, in the interests of providing as much spatial or depth coverage of a site as possible within a given time or budget constraint, for example for hard-layer detection or pilot-hole drilling (for detection of shallow gas);
- to minimize the potential for a shallow gas incident where the rapid extraction of wireline tools from the seabed (swabbing effect) can induce a shallow gas release (see A.5.4.4).

The selection of drilling equipment and procedures shall be based on the drilling objectives given in the project specifications, with due consideration of the range of expected soil conditions and drilling hazards that can be encountered. For sampling by rotary core drilling, the drilling system and the associated sampling techniques can follow the requirements of ISO 22475-1 (mainly for onshore and nearshore soil investigations).

Further guidance on the selection of drilling equipment and procedures is provided in Annex A.

7.4 Drilling operations plan

The purpose of the drilling operations plan is twofold:

- 1) during the pre-fieldwork phase, to provide assurance that:
 - required information is in place;
 - the proposed solution is capable of meeting the objectives of drilling and logging;
 - due consideration has been paid to potential drilling hazards;
 - contingency plans are in place in the event of foreseeable drilling-related problems;
- 2) during the fieldwork phase, to control the execution of the drilling and borehole works.

The level of detail required depends on the complexity of the marine soil investigation, on the tools and techniques to be employed, and on whether any new or modified equipment or procedures are required.

The plan should not stop the continuous assessment of data quality and if necessary, the adjustment in operational procedures if required during the completion of the work. For the range of possible soil conditions, the drilling operations plan shall describe the following components, where applicable:

- a) drilling equipment and operational details (see Clause A.7);
- b) borehole construction plan, describing the sequence of borehole construction (with drill string details and drill bit selection), identification of possible drilling problems, borehole abandonment procedures and grouting procedures, and contingencies or remediation options (e.g. in the event of stuck string or tool lost in the borehole);
- c) mud plan, with the drilling fluid solution adopted and criteria for change of fluids considering potential for adverse chemical reaction (see Clause A.7);
- d) requirements for recording and presentation of drilling parameters;
- e) schedule for borehole geophysical logging, *in situ* testing and sampling;
- f) shallow gas plan if potential for a shallow gas release exists (see 5.4.4);
- g) grouting plan, with the grouting fluid/additives selected, grouting procedures and requirements for grout testing (i.e. grout cube crush tests and acceptance criteria).

7.5 Recording of drilling parameters

During the process of borehole drilling, the system operational and performance parameters shall be recorded. Recording can be done manually (usually by the driller) or by using an automated logging system.

When depth resolution of logged parameters better than 0,5 m is required, use of automated logging is the preferred method.

The recorded parameters and information shall include the following:

- a) geographical location and borehole name;
- b) water depth (e.g. relative to LAT or MSL);

- c) type of drilling fluid and properties;
- d) type of drill bit and bottom hole assembly;
- e) time (dd/mm/yyyy hh:min);
- f) penetration (depth to bottom of borehole) (m);
- g) ROP (m/min);
- h) time to drill each interval (min);
- i) duration and reason for any stoppage (min);
- j) drilling fluid pressure at the output of the pump (kPa), where available;
- k) drilling fluid circulation rate (input) (l/min), where available;
- l) drilling fluid recovery rate (l/min), only for riser drilling with recirculation of drilling fluid, and where available;
- m) drill head rotational torque (N·m), where available;
- n) drill head rotational speed (revolutions per min), where available;
- o) weight on bit (kN), where available.

The accurate recording of drilling parameters can provide a valuable data set for use in interpolation/extrapolation of soil data and detection of layering. An example of such application for detection of hard layers in carbonate material is given in Becue et al. (1988) ^[112].

7.6 Borehole geophysical logging

7.6.1 General

Depending upon project-specific requirements, geophysical wireline logging can be employed. Typically, this technique provides enhanced geological and engineering detail over the logged borehole section. Further guidance is provided in Clause A.7.6.

The project specifications should consider the following, where applicable:

- a) required measurement types and corresponding logging tools;
- b) applicability of logging tool for expected setting, including metocean conditions, depth below seafloor and soil conditions;
- c) deployment method (e.g. wireline, open- or cased-borehole logging);
- d) minimum number of measurements per logged depth section;
- e) required sequence, direction and speed of lifting (or lowering) of the tool for logging;
- f) accuracy of depth below seafloor;
- g) required correlations between measurements;
- h) number of tools or length of logging section per run;
- i) whether a heave-compensated logging line is required.

7.6.2 Reporting of results

The report on logging results shall include, where applicable:

- a) geographical location and borehole name;
- b) coordinates, including coordinate reference system;
- c) water depth (e.g. relative to LAT or MSL);

- d) measurement results;
- e) characteristics of the borehole geophysical logging system, including deployment method;
- f) details of borehole conditions according to Clause 7;
- g) statement on corrections applied to the data;
- h) details of the processing performed on the data;
- i) distinction on open-hole logging or in-pipe logging;
- j) sequence, direction and rate of travel of the logging probes in the borehole;
- k) depth accuracy class according to 6.3.3.;
- l) definitions, formulae, assumptions and limitations of derived parameter values and applied correlations between measurements.

8 *In situ* testing

8.1 General

In situ tools can be deployed via two alternative methods:

- 1) non-drilling mode, in which tool penetration is initiated at the seafloor and penetrated to refusal, or to a predetermined depth;
- 2) drilling mode, where the tool is lowered down a predrilled borehole and *in situ* testing is initiated at the bottom of the borehole.

The recommendations and requirements given in Clause 6 should be taken into account when planning and performing *in situ* tests. For tests undertaken in drilling mode, Clause 7 should also be consulted.

Calibration of *in situ* probe sensors shall be performed in a calibration laboratory that meets the requirements of ISO/IEC 17025. The calibration laboratory should be accredited for the calibration and verification activities required for *in situ* tools.

In situ tools and probes shall be manufactured using corrosion resistant material applicable to marine conditions.

8.2 General requirements for the documentation of *in situ* tests

For each test, the following information shall be recorded and reported in addition to the test results:

- a) site geographical details, including:
 - geographical location;
 - borehole or test title;
 - coordinates, including project coordinate system (e.g. WGS 84);
 - water depth (e.g. relative to LAT or MSL);
- b) equipment details (as applicable):
 - deployment mode;
 - cone penetrometer class according to Table 2;
 - measuring intervals for calibration of the sensors for test measurements;
- c) test details (as applicable):
 - test type;

- time and date;
- test/stroke number;
- current borehole depth;
- tool type (geometry/capacity);
- unique equipment/tool number;
- stop criteria/reason for termination;
- test category according to classification provided in Table 4.

In addition, the following information should be recorded:

- a) additional site geographical details, including facility name;
- b) additional equipment details (as applicable):
 - equipment name;
 - type of penetration system;
 - borehole progression method;

Reference shall be made to any deviations from the requirements of this document or the project specifications, where identified, including testing procedures and tool wear or damage.

8.3 Cone penetration test

8.3.1 General

This subclause covers cone penetration tests performed with a CPT and with a CPTU.

8.3.2 Equipment

The standard cone penetrometer is defined as having a nominal cross-section, A_c , of 1 000 mm². The geometry of the standard cone penetrometer and allowable tolerances should be as given in ISO 22476-1.

Cone penetrometers with a diameter between 25 mm ($A_c = 500$ mm²) and 50 mm ($A_c = 2\,000$ mm²) can be used for special purposes, without the application of correction factors. The geometry and tolerances given for the nominal 1 000 mm² cone penetrometer should be linearly scaled in proportion to the diameter. The friction sleeve shall be placed immediately behind the cone. The dimensions and tolerances for the friction sleeve shall be as given in ISO 22476-1.

The cone penetrometer should be manufactured to a surface roughness, R_a , of $0,4\ \mu\text{m} \pm 0,25\ \mu\text{m}$. The surface roughness refers to average roughness, R_a , determined by a surface profile comparator according to ISO 8503 or equivalent.

For pore pressure measurements, the filter element location on the cylindrical part immediately behind the conical part is recommended. Pore pressure measured at this location is denoted u_2 . Pore pressures can also be measured on the cone face (u_1) and/or just above the friction sleeve (u_3). The location of the filter element(s), dimensions and tolerances should be as given in ISO 22476-1.

A cone penetrometer can be designed solely for the measurement of cone resistance, if the following conditions are met: (1) downhole deployment in drilling mode and (2) ground conditions such that cone resistance values exceeding 120 MPa can be expected.

NOTE 1 The permission for a cone penetrometer with limited sensors allows the use of more robust cone penetrometers. The primary benefit would be increased CPT coverage in hard ground, i.e. an increase in safe deployment limits.

The penetrometer tip and adjoining rod(s) should have the same diameter for at least 400 mm behind the tip for the 1 000 mm² cone penetrometer. For other size cones, this distance should be scaled linearly in proportion to the diameter.

NOTE 2 Changing rod diameter at a distance of less than 400 mm (for standard 1 000 mm² cone penetrometers) can influence the directional stability of the system and possibly the cone resistance.

8.3.3 Test procedures

8.3.3.1 Selection of equipment and procedures

Equipment and procedures to be used should be selected considering the expected ground conditions and the project requirements.

Cone penetration test results shall be classified considering the cone penetrometer uncertainty characteristics and diagnostic checks of the sensors during the field work:

1. cone penetrometer class;
2. test category.

The cone penetrometer class shall be determined based on documented calibration results and uncertainty analyses as described in 8.3.3.3.

Recorded observations and measurements during test preparation and execution shall be used to evaluate the test category of the CPT/CPTU performed. Description of the documentation required is given in 8.3.4. Annex A provides guidance for selection of cone penetrometer class and provides an indication of test categories that can be achieved.

8.3.3.2 Calibration and verification requirements

The cone penetrometer shall be calibrated in accordance with Annex B for the following measurands, where applicable:

- a) cone resistance;
- b) sleeve friction;
- c) pore pressure;
- d) area ratios of the cone (a) and of the friction sleeve (b);
- e) inclination.

NOTE Inclination is defined as the angular deviation of the cone penetrometer from the vertical.

Calibration should be carried out regularly; at least every six months after first use or if sensors are overloaded or showing signs of malfunction.

Calibration shelf-life of an unused cone penetrometer should not exceed 12 months.

Verification of the cone penetrometer performance shall be conducted according to Annex B.

Test reports for calibration and verification shall include:

- a) description and identification of the cone penetrometer;
- b) identification of the calibration laboratory (or calibration laboratories);
- c) description of the calibration laboratory environment during calibration, average temperature and range of variation;
- d) identification and uncertainty characteristics of reference instruments used for calibration and verification;
- e) details of any adjustment or repair made prior to calibration;

- f) date of calibration, measuring intervals for calibration and calibration results;
- g) analysis of the uncertainty of the calibration for each of the penetrometer sensors;
- h) cone penetrometer class;
- i) statement of conformity with this document;
- j) statement identifying how the measurements are metrologically traceable.

8.3.3.3 Cone penetrometer class conformity assessment

Each cone penetrometer shall have a statement of conformity for at least one of the cone penetrometer classes of Table 2. The statement of conformity shall be included in a calibration test report or calibration certificate according to 8.3.3.2.

Conformity to a cone penetrometer class shall be determined after each calibration of the cone penetrometer. The expanded measurement uncertainty for each cone penetrometer measurand shall include the uncertainty contributions defined in Table 3. The expanded measurement uncertainty for the statement of conformity shall be calculated according to formulae provided in Annex B.

Table 2 — Classification of cone penetrometers under laboratory conditions

Cone penetrometer class	Measurand	Allowable maximum expanded measurement uncertainty ^a	Ambient temperature stability ^c	Transient temperature stability ^c	Bending influence ^c
		$U_{qc: \text{class}}$ $U_{fs: \text{class}}$ $U_{u: \text{class}}$	Δa_{qc} or Δa_{qcc} Δa_{fs} , or Δa_{fsc} Δa_u or Δa_{uc}	Δt_{qc} or Δt_{qcc} Δt_{fs} or Δt_{fsc} Δt or Δt_{uc}	Δb_{qc} Δb_{fs} Δb_u
1+	Cone resistance	35 kPa or 1%	1 kPa/°C	5 kPa/°C	0,3 kPa/N
	Sleeve friction	5 kPa or 1%	0,1 kPa/°C	0,5 kPa/°C	0,1 kPa/N
	Pore pressure	25 kPa or 0,5%	0,1 kPa/°C	0,5 kPa/°C	0,05 kPa/N
1	Cone resistance	35 kPa or 1%	2 kPa/°C	10 kPa/°C	0,3 kPa/N
	Sleeve friction	5 kPa or 1%	0,1 kPa/°C	0,5 kPa/°C	0,1 kPa/N
	Pore pressure	25 kPa or 0,5%	0,1 kPa/°C	0,5 kPa/°C	0,05 kPa/N
2	Cone resistance	100 kPa or 2%	10kPa/°C	50kPa/°C	1 kPa/N
	Sleeve friction	15 kPa or 2%	0,5kPa/°C	2,5kPa/°C	0,5 kPa/N
	Pore pressure ^b	50 kPa or 1%	1kPa/°C	2,5kPa/°C	0,1 kPa/N
^a The allowable maximum expanded measurement uncertainty is the larger value of the two quoted. The relative uncertainty applies to the measured value and not the measuring range. ^b Pore pressure applies only to CPTU. ^c The values of ambient temperature stability, transient temperature stability and bending error represent the maximum allowable for each cone penetrometer class.					

Conformity to a cone penetrometer class shall apply when all the following requirements are met:

- a) each of the expanded measurement uncertainty values meets the requirements of Table 2 for each of the measurands for a given cone penetrometer class;