



Exploration & Production

GENERAL SPECIFICATION

SURVEYS

GS EP GEO 702

Requirements for design and installation of skirted foundations and suction anchors

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1. Scope

1.1 Objective

This document gives the minimum requirements applicable for the design and installation of skirted foundations and suction anchors, with the objective to obtain satisfactory and consistent quality in the studies and works to be provided by the Contractor in charge of design or installation of such structures.

It covers the following foundations and anchors:

- Relatively large skirted foundations, made of steel or concrete, for fixed jacket structures or gravity-based structures
- Skirted foundations of limited size for subsea production structures and manifolds
- Suction anchors used in temporary moorings for exploration drilling rigs (MODUs)
- Suction anchors used in permanent moorings for production structures (e.g. FPSO/FSO, TLP, semi-submersible FPU, or other DDCUs such as the SPAR).

This General Specification applies to:

- Acquisition and interpretation of specific site and soil data
- Geotechnical and structural design considerations
- Requirements for monitoring of the installation behaviour.

Deviations from any of the requirements defined herein shall be treated as non-conformances in accordance with Company procedures.

1.2 Abbreviations

The following abbreviations are used:

- **API** American Petroleum Institute
- **CPTU** Cone Penetration Test with pore pressure measurement
- **DDCU** Deep Draught Caisson Unit
- **FPSO/FSO** Floating Production Storage and Off-loading vessel
- **FPU** Floating Production Unit
- **ISO** International Standard Organisation
- **MODU** MOBILE Drilling Unit
- **MSCL** Multi Sensor Core Logging
- **OLT** Off-Loading Terminal (buoy)
- **ROV** Remotely Operated Vehicle
- **SPS** Subsea Production System
- **TLM** Taut Leg Mooring
- **TLP** Tension Leg Platform



2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

This specification is complementary to the following documents:

- **GS EP STR 100** and **GS EP STR 101** for design of offshore jackets and subsea structures
- **GS EP SPS 001**, **GS EP SPS 002** and **GS EP GEO 701** for subsea production systems
- **GS EP GEO 101** and **GS EP GEO 201** for site investigation equipment and procedures.

Therefore, this specification shall be read in conjunction with above documents and the other Company specifications and standards identified herein.

Standards

Reference	Title
ISO 19900	Petroleum and Natural Gas Industries - Offshore Structures - Part 1: General Requirements
ISO 19901 (Parts 4; 7)	Petroleum and natural gas industries - Specific requirements for offshore structures - (Parts 4; 7)
ISO 19902	Petroleum and Natural Gas Industries - Fixed Steel Offshore Structures
ISO 19904-1	Petroleum and Natural Gas Industries - Floating Offshore Structures - Part 1: Monohulls, Semi-submersibles and Spars

Professional Documents

Reference	Title
AISC ASD	Manual of Steel Construction - Allowable Stress Design
API Bull 2U	Bulletin on Stability Design of Cylindrical Shells
API RP 2A LRFD	Recommended Practice for Planning, Designing and Constructing Fixed Structures - Load and Resistance Factor Design
API RP 2A WSD	Recommended Practice for Planning, Designing, and Constructing Fixed Structures - Working Stress Design / Load and Resistance Factor Design
API RP 2GEO	Geotechnical and Foundation Design Considerations
API RP 2SK	Recommended Practice for Design and Analysis of Stationkeeping Systems for Floating Structures



Reference	Title
API RP 2T	Recommended Practice for Planning, Designing and Constructing Tension Leg Platforms
DNV-RP-E303	Recommended Practice for Design and Installation of Suction Anchors

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Andersen and Jostad (2002)	"Shear Strength Along Outside Wall of Suction Anchors in Clay after Installation", ISOPE 2002
Andersen and Jostad (2004)	"Shear Strength Along Inside of Suction Anchor Skirt Wall in Clay", OTC paper 16844, 2004
Colliat and Colliard (2010)	"Set-Up of Suction Piles in Deepwater Gulf of Guinea Clays", ISFOG 2010
Colliat et al. (2010)	"Centrifuge Testing of Suction Piles in Deepwater Nigeria Clay - Effect of Stiffeners and Set-Up Time", ISFOG 2010
Deng and Carter (2002)	"A Theoretical Study of the Vertical Uplift Capacity of Suction Caissons", ISOPE 2002
Raines et al. (2005)	"Centrifuge Modelling of Suction Piles in Clay", ISFOG 2005

Total General Specifications

Reference	Title
GS EP GEO 101	Offshore Geotechnical Soil Survey
GS EP GEO 201	Offshore Geophysical Surveys
GS EP GEO 701	Geotechnical Data and Foundation Design Considerations for Subsea Production Systems and Pipelines



Reference	Title
GS EP SPS 001	Design Philosophy and Requirements for Subsea Stations
GS EP SPS 002	Design of Subsea Structures
GS EP STR 100	Offshore Steel Platforms - General
GS EP STR 101	Design of Offshore Jacket and Subsea Structures

3. Requirements for site and soil investigation

The general offshore site and soil investigation equipment and procedures shall be in agreement with the Company Specifications:

- **GS EP GEO 201** for geophysical site survey
- **GS EP GEO 101** for soil sampling and laboratory testing, in-situ testing, as well as data interpretation and foundation design.

The following site specific data shall be determined:

- Seabed features and seabed topography
- Type and thickness of sea bottom and subsurface soils, including the possible presence of obstacles (e.g. boulders) and possibly detrimental soil conditions, such as sand lenses or cemented layers.

The scope of work and extent of the soil investigation shall depend on the soil type, soil strength and natural variability, but, taking into account the relatively shallow type of foundations and anchors of concern, the data acquisition methods shall focus on the detailed determination of the nature and characteristics of the first 20-40 metres of sediments (i.e. corresponding to the anticipated skirt height plus two caisson diameters).

The soil investigation shall combine in-situ testing (e.g. CPTU, vane, T-bar) and high quality sampling. Equipment and procedures allowing continuous profiling and sampling shall preferably be used.

Use of correlations to determine soil characteristics and strength from in-situ testing results, to be documented by Contractor, shall be based on local experience and site specific data.

Prior to start of testing, the quality of soil specimen shall be determined in the onshore laboratory, with a procedure (e.g. MSCL logging, X-ray logging, or other) to be submitted to Company for approval. Advanced laboratory testing, including but not limited to direct simple shear, soil-steel interface ring shear and cyclic triaxial testing, shall be performed on the highest quality samples. The lowest quality samples shall be used to perform classification tests, as well as tests on remoulded soil for simulating the situation during skirt penetration.

For the tests performed on intact soil specimen, the effect of sample disturbance on test results shall be taken into account, in particular for soft sediments from deep water sites where disturbance from stress relief and gas expansion is possible.

Specific geotechnical concerns shall be addressed, in particular:

- Strength anisotropy
- Permeability and consolidation characteristics

- Sensitivity and thixotropy
- Strain rate effect
- Creep effect under sustained loading
- Cyclic loading effect
- Sea bottom hazards, such as risk of scour and sliding.

4. Requirements for geotechnical design

4.1 General requirements

The above referenced ISO and API documents shall be used as guidelines only for general geotechnical design requirements, since they do not address skirted foundations and suction anchors specifically. In particular, the conventional ' α^*Cu ' and 'p-y/t-z' analyses for foundation piles can only be used for preliminary design, NOT for the final detailed design of skirted foundations.

The following requirements apply for all types of skirted foundations and suction anchors:

- The geotechnical design parameters shall be provided in a specific Design Brief Report, which shall be submitted to Company for approval before start of the design studies. This report shall include at least:
 - Scope and purpose
 - Complete list of applicable design rules and regulations, including specific requirements from the Certifying Company (if any)
 - Design principles, with minimum safety coefficients (for a working stress design approach) or minimum soil and load factors (for a load resistance factor design approach)
 - Complete list of load combinations, with identification of design loading conditions
 - Summary of the soil investigation results, and assessment of design strength profiles, with lower, best estimate and upper bound profiles, for taking into account the possible natural variation and range in design parameters
 - Description of the calculation programmes to be used, with the basis for the validation/calibration of the proposed design method
 - Material properties for structural design considerations
 - Installation tolerances.
- For optimised design, different caisson geometry, i.e. different values of the height-to-diameter ratio, shall be considered.
- The effect of internal soil heaving during skirt penetration by suction under-pressure, as well as the consequence of possible external scouring (if any), shall be taken into account in the determination of the minimum skirt length.
- For all types of SPS considered, and in agreement with the Project specifications, the skirted foundation capacity shall be sufficient to overcome vertical and horizontal loading from externally-applied forces such as trawl board impact or snagging. Drilling operations

shall be specifically considered for pre-drilling templates, as well as retrieval operations at the end of the field lifetime (if required).

- Sea bottom movements, possibly due to earthquakes and/or slope instability, shall not cause loss of foundation support with soil liquefaction or excessive displacements.
- Specific features, which can have a detrimental effect on the external or internal soil-steel interface friction resistance shall be avoided, in particular:
 - No paint shall be used for corrosion protection (use of sacrificial anodes only)
 - Size and number of internal stiffeners shall be minimised
 - Change in skirt wall thickness shall only be allowed along the internal skirt wall.

4.2 Calculation of ultimate holding capacity

4.2.1 General

Holding capacity calculations shall be performed using limit equilibrium models corrected for 3-D effects. Such models shall take into account the following aspects:

- Uniform soil conditions, or multi-layered soils
- Any types of failure surface, and identification of the most critical failure surface
- Undrained capacity under short term or dynamic (i.e. quick) loading condition
- Drained capacity under static (i.e. long term or sustained) loading condition
- Effect of soil strength anisotropy
- Effect of cyclic loading
- Effect of soil consolidation after installation, including calculation of immediate and long term settlements
- Effect of interaction between vertical and lateral loading.

The ultimate holding capacity and load-deflection behaviour under failure condition, as calculated with the limit equilibrium model, should be checked and validated by a 3-D elasto-plastic finite element analysis model. Use of 2-D finite element calculations corrected for 3-D effects can be acceptable when they are validated by previous experience (to be documented by Contractor).

With respect to the ultimate holding capacity of the skirted foundations or suction anchors, the design studies shall address the following points:

- Relevant failure modes and most critical loading combinations shall be identified.
- The immediate holding capacity at time of installation shall be calculated by considering the effect of reduced soil-steel friction resistance with soil disturbance during skirt penetration. The increase in holding capacity with time shall be determined from the thixotropy and consolidation characteristics of the soil.
- The undrained or partially undrained ultimate holding capacity shall be calculated by considering both conditions where: (a) passive suction cannot develop inside the caisson, i.e. when the top cover is assumed as being open or leaking under service loading condition, and (b) passive suction is allowed to develop inside the caisson, i.e. when the

top cover is assumed as being tightly closed under service loading condition. In the latter case, the top cover opening(s), to be closed after the self-weight penetration phase, shall be designed to properly sustain the passive suction, or the designer shall take into account the potential consequence of loss of suction on the holding capacity.

4.2.2 Skirted foundations for fixed jacket or gravity-base structures

For fixed jacket or gravity-base structures with skirted foundations under combined vertical, horizontal and moment loading conditions, the following specific points shall be addressed:

- The design of the foundation caisson shall ensure that limit state criteria are satisfied, including requirements with respect to stress, displacement and fatigue.
- The ultimate holding capacity calculations shall consider both the static loading condition, and the cyclic loading condition with accumulation of pore pressures generated by successive storms.
- Appropriate seabed foundation matrices shall be defined for studying the interaction between the foundation caissons and the structure. Such matrices shall reflect the geometric, stiffness and damping characteristics of the foundation caissons, and shall be consistent with the level of sophistication used for the rest of the structure.
- The stability of the structure at time of installation shall be checked, considering different penetration steps, i.e. seabed touch-down, partial, and total skirt penetration.
- The structure shall be supported without incurring excessive immediate deformations or long term total settlement. Both cases with the foundation caissons being open and closed shall be considered for calculating the soil consolidation and structure settlement as a function of time.

4.2.3 Suction anchors under inclined loading condition

Holding capacity calculations for suction anchors which are submitted to inclined loading situations with a significant vertical loading component shall address the following points:

- The position of the anchor pad-eye at the mooring line attachment point shall be determined for optimising the ultimate holding capacity by minimising the anchor rotation.
- The mooring chain/cable configuration of the line length embedded into the soil, the line angle at the anchor pad-eye, and the load component taken by friction along this length, shall be determined with a validated calculation model.
- The risk of formation of a vertically open crack at the rear side of the caisson (i.e. opposite to the anchor pad-eye), and the potential consequence of losing passive suction at the anchor tip with water flow from the crack, shall be evaluated and mitigated, for example by lowering the chain pad-eye so that the anchor would tend to rotate against the rear side.
- The effect of installation tolerances (i.e. anchor tilt and mis-orientation) on the ultimate holding capacity shall be taken into account. Unless otherwise indicated in the Project requirements, a minimum value of $\pm 5^\circ$ on tilt angle and heading shall be considered.

Note: A larger installation tolerance of up to $\pm 7^\circ$ to 10° may be considered when the suction anchor is planned to be installed together with the mooring line (to be defined as part of Project specific requirements). In such case, the structural design analysis for the chain pad-eye shall be given special attention.

4.2.4 Suction anchors under permanent or sustained tension loading condition

For suction anchors under permanent or sustained tension loading condition (e.g. for TLPs and riser towers or single risers), the following specific points shall be addressed:

- The specific bias (uncertainty) safety B factor for TLP pile foundations in [API RP 2T](#) is also applicable to caissons. Considerations for such biased (i.e. increased) safety include the effect of cyclic degradation and sustained tension with respect to soil creep behaviour.
- Suction anchors shall derive their uplift resistance by a combination of self-weight/ ballast and soil pull-out capacity from both soil-pile friction and passive suction. The respective distribution of loads (i.e. pre-tension, long term static loading, and short term dynamic storm loading) between the resisting components shall be defined with respect to engineering judgement, appropriate analyses, and experimental or prototype results.
- For anchors under sustained tension loading, where the long term drained behaviour is the governing condition, the soil-pile friction resistance shall be calculated using an effective stress model that captures this behaviour.

Note 1: Several case studies of retrieval of full-scale suction piles up to 3 ½ years after installation in high plasticity Gulf of Guinea deepwater clays are given in [Colliat & Colliard \(2010\)](#). It shows that the soil-pile interface friction factor α reaches a maximum value of 0.55, which is lower than the interface friction set-up factor of 0.65 proposed by [Andersen & Jostad \(2002, 2004\)](#).

Note 2: [Deng & Carter \(2002\)](#), [Raines et al \(2005\)](#) and [Colliat et al \(2010\)](#) show that the mobilisation of full passive suction at the tip of a suction pile requires large vertical displacements (i.e. several metres). One shall then be cautious when defining the undrained pullout capacity of a skirted pile with analytical calculations where the external friction resistance mobilised under a small vertical displacement is added to passive suction requiring large vertical displacements. In absence of specific results from the Project site and soil under consideration, the undrained pullout capacity of a skirted pile shall be calculated with a maximum of 50% of passive suction mobilised at the pile tip. Any analytical approach shall be validated/ calibrated against finite element analyses taking into account a time-dependent effective stress approach (to be submitted to Company for approval). In particular, the [Deng & Carter \(2002\)](#) approach cannot be considered as valid on the sole basis of a comparison of the non-dimensional coefficient T_k (defined as the ratio of coefficient of consolidation of the soil, c_v , to the product of the loading rate and the caisson diameter) since soil specific characteristics may apply to differentiate between undrained, drained and partially drained conditions.

- The effect of installation tolerances (i.e. anchor tilt and heading) on the ultimate holding capacity shall be taken into account. Unless otherwise indicated in the Project requirements, a minimum value of $\pm 5^\circ$ on tilt angle and heading shall be considered.
- Time dependent uplift displacement of the anchor shall be estimated. When a partially drained behaviour governs under sustained or permanent tension loading with the development of passive suction at the skirt tip being uncertain, both cases with the caissons being open and closed shall be considered for calculating the vertical displacement. The total long term displacement over the field lifetime duration shall be compatible with the limit state criteria.

4.2.5 Skirted foundations for small sub-sea structures

For other types of skirted foundations, in particular for relatively small sub-sea structures, a less sophisticated design approach may be sufficient, where only limit equilibrium models are applied.

The following points shall be addressed:

- The foundation stability shall be checked under both (a) vertical compression loading (from the SPS dead weight), and (b) horizontal and moment loading (e.g. from flow-lines expansion) conditions.
- For multi-caisson structures on a sloping sea bottom, the effect of the seabed gradient shall be taken into account for defining the minimum skirt length with respect to the design penetration.
- The effect of installation tolerances (i.e. anchor tilt and mis-orientation) on the ultimate holding capacity shall be taken into account. Unless otherwise indicated in the Project requirements, a minimum value of $\pm 5^\circ$ on tilt angle and heading shall be considered.
- The horizontal load-deflection behaviour and long term consolidation settlement shall be compatible with the limit state criteria of the SPS. In particular, due attention shall be paid to tie-in with jumpers and/or flow-lines which shall have sufficient flexibility to withstand the settlements of the foundation caisson. Both cases with the caisson being open and closed shall be considered for calculating the soil consolidation and settlement as a function of time.

5. Requirements for penetration and retrieval analyses

5.1 Penetration analysis

Skirt penetration analysis shall address the following aspects:

- Calculation of the soil resistance to penetration of the caisson. Evaluation of the friction resistance shall take into account the reduction in shaft friction due to both the soil sensitivity and the influence of internal stiffeners. The influence of the lowest internal stiffener shall be taken into account for calculating end bearing resistance.

Note: The penetration analysis shall be carried out with the final configuration of the caisson given by the detailed structural analysis. The calculation method for evaluating the resistance to penetration shall be calibrated on previous experience with similar soil conditions, but both lower and upper bound soil strength profiles shall be considered for calculating the resistance to penetration with a reasonable degree of conservatism.

- Evaluation of penetration of the caisson under self-weight and by suction under-pressure.
- Calculation of the maximum suction under-pressure required for reaching the design target depth.
- Calculation of the maximum allowable suction under-pressure versus depth, with respect to internal soil heaving (in cohesive soils) or piping (in sandy soils).

Stability of the caisson at time of seabed touch-down shall be addressed in detail, in particular with respect to:

- Evaluation of minimum openings required on the caisson top cover and at the bottom of the skirt, for free water evacuation capacity during self-weight penetration as a function of landing velocity. Depending on the dynamic amplification behaviour with respect to the caisson dimensions and swell conditions, a heave compensating system shall be included in the handling/lifting system in order to limit vertical heaving of the caisson at touch-down approach.
- Evaluation of installation impact force as a function of landing velocity, and check of bearing capacity failure in case of lack of touch-down control, in particular at deep water sites with soft soils.

5.2 Retrieval analysis

As a contingency during installation, retrieval of the skirted foundation or anchor by over-pressurising shall be considered.

The skirt retrieval analysis shall address the following aspects:

- Calculation of the soil resistance to retrieval of the caisson
- Calculation of the maximum over-pressure required for caisson retrieval versus penetration depth.

In cohesive soils, the retrieval analysis shall take into account the increase in soil strength and friction resistance with set-up time. For temporary moorings of drilling MODUs, retrieval can be required several months after installation, which shall be taken into account in the retrieval and structural analyses in agreement with the Project specifications. For other types of caissons or suction anchors, retrieval for anchor relocation may be required up to one week after installation (to be defined in Project specific requirements).

In the event that the skirted foundation or suction anchor has to be retrieved after being installed out of tolerances, or for any other reasons, the retrieval analysis shall also address the minimum distance required for re-installing the caisson in an area where the in-situ soil and the holding capacity of the caisson shall not be influenced by the initial installation operations.

6. Requirements for structural design

6.1 General requirements

This section only covers the structural design of skirted foundations and suction anchors made of cylindrical steel shells, which shall be performed in accordance with the [API Bull 2U](#) and the [AISC manual](#).

The detailed structural design calculations shall be performed using soil structure interaction analyses, with a non-linear elasto-plastic soil model applied in axi-symmetric finite element calculations. For local design checks, a fine meshing shall be performed using thin shell elements.



The following general requirements apply:

- The structural design conditions shall include: (a) load-out, transportation, lifting and deployment at the site, (b) skirt penetration analysis, (c) retrieval analysis (contingency), (d) in-place analysis under operating and extreme conditions, and (e) fatigue analysis.
- Structural design shall cover: (f) global structure design, and (g) local design checks, in particular for areas where strong stress concentrations are expected, i.e. (g1) caisson top cover, (g2) connection between caisson and structure or mooring line, and (g3) internal stiffeners.
- Soil stiffness and soil reaction profiles, for radial normal stresses and tangential/vertical shear stresses for both external and internal skirt wall, shall be used as input data. The soil reaction profiles and deformation of the steel cylinder shall be derived from 3-D elasto-plastic finite element analyses, for both installation and operating conditions.
- Fatigue analysis of critical elements shall be based on finite element analyses and on relevant S-N curves.

6.2 Requirements for penetration, retrieval, and in-place analyses

The structural design requirements with respect to penetration, retrieval, and in-place analyses for skirted foundations or suction anchors include the following points:

- The global caisson shall be designed for supporting the maximum allowable installation suction under-pressure and retrieval over-pressure with adequate safety margin.
- The top cover thickness and framing shall be checked with respect to stress and deflection limit state criteria.
- The overall cylinder shell structure shall be checked with respect to buckling. When using relatively thin shell plates where internal stiffening is required, different types of stiffeners can be considered, including ring stiffeners and/or vertical plates. In any case, but more particularly for ring stiffeners, the dimensions and number of stiffeners shall be minimised in order to limit as much as possible the reduction in internal soil-steel friction from soil disturbance at time of skirt penetration.
- For suction anchors, the anchor pad-eye area shall be designed in such a way that the installation tolerance on mis-orientation can be maximised. Unless otherwise indicated in the Project requirements, the structural design shall allow for a minimum value of $\pm 5^\circ$ on anchor heading.

The structural design report to be provided by Contractor shall include the detailed input data and material properties, the description of 3-D finite element modelling, the detailed calculation results and safety coefficients/utilisation ratios, and the design drawings.

7. Requirements for monitoring of installation behaviour

7.1 General requirements

Accurate control and monitoring of installation operations is necessary for ensuring that the skirted foundations and anchors reach their target design penetration within tolerances. The following general requirements apply to the suction equipment system:

- Accurate measurement of suction under-pressure, i.e. with necessary precautions to limit as much as possible the hydraulic losses between the caisson and the differential pressure transducer. Such hydraulic losses shall be measured at various flowrates by running the suction pump in its installation configuration on a skirted foundation or suction anchor near the sea bottom, and the measurements of suction under-pressure shall be corrected accordingly.
- The pump characteristics shall be adapted to the maximum predicted values of suction under-pressure, and the pump flow capacity should be as large as possible since this will directly influence the rate of penetration.
- The pumping direction (i.e. pumping-out for suction penetration and pumping-in for retrieval by over-pressurising) shall be easily reversible in the event that the caisson needs to be pulled-out from the soil.

The suction equipment and monitoring system shall be either fixed directly onto the caisson top cover, with umbilical link to the installation naval support at sea surface (generally in shallow water), or carried by an ROV (at deep water sites).

For deep water operations with ROVs, a minimum of two ROVs shall be used, with the primary ROV carrying the suction pump and the second one for penetration readings and back-up. ROV-friendly procedures shall be defined, in particular with easy access for closing/opening of check valves on the caisson top cover and for suction pump operation.

7.2 Monitoring equipment and reporting

The minimum instrumentation required to accurately monitoring the installation behaviour of skirted foundations and suction anchors include:

- Positioning beacon (or ROV positioning when one ROV is docked on the pile top during landing and penetration), for control of the as-installed location
- Inclinator(s), for measurement of pitch, roll, and tilt angle
- Gyro-compass, for control of heading
- Total pressure transducer, for measurement of water depth and penetration
- Differential pressure transducer, for control of the installation suction and retrieval over-pressure (if required)
- Paintings on external skirt wall (every 0.25 m minimum and with target penetration marking) for penetration readings with ROV camera visuals.

In agreement with the Project requirements, a number of back-up equipment shall be available for providing a level of redundancy of the monitoring instrumentation.

The complete installation results shall be provided by Contractor in an as-built report, together with a recall of the installation tolerances. In the same as-built report, the installation results



shall be compared to the original predictions, in particular with respect to self-weight penetration and required maximum suction under-pressure. Significant differences between predictions and installation results shall be addressed, with particular concern about the as-installed holding capacity as compared to the required ultimate design capacity.

8. Other references

Following documents are applicable:

- Standards: [ISO 19900](#), [ISO 19901-4](#), [ISO 19901-7](#), [ISO 19902](#), [ISO 19904-1](#)
- Professional Documents: [API RP 2A LRFD](#), [API RP 2A WSD](#), [API RP 2GEO](#), [API RP 2SK](#), [DNV-RP-E303](#).