



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS STR 432

Installation of piles for offshore steel structures Drilled and grouted piles
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1. Scope

The document defines the minimum requirements to perform fabrication and installation of drilled and grouted piles for fixed offshore steel structures.

The document also defines references for obtaining satisfactory and consistent quality in the reports to be provided by the CONTRACTOR in charge of pile installation works.

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.

Recognition of reference documents

Only the main reference documents are mentioned. The CONTRACTOR shall be responsible for complying with all secondary reference documents dealing with the subject of this document.

Unless otherwise indicated in the detailed contractual conditions, all the reference documents to be used, as well as their supplements, shall be the latest editions.

Standards

Reference	Title
ISO	INTERNATIONAL STANDARD ORGANISATION
ISO 1000	Specification for SI Units and Recommendations for the Use of their Multiples and of Certain other Units
ISO 9001:2000	Quality Management Systems. Requirements
ISO/DIS 19900	International Standard for Offshore Structures – Part 1: General Requirements
DNV	DET NORSKE VERITAS
	Rules for Planning and Execution of Marine Operations
API	AMERICAN PETROLEUM INSTITUTE
API RP 2A - WSD	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms. Working Stress Design

Professional Documents

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS STR 301	Fabrication of Offshore Steel Structures
GS STR 431	Installation of Piles for Offshore Steel Structures Driving

3. General

Proper installation of the foundation piles is vital to the life and permanence of the platform and requires each pile to be driven or drilled and grouted to the design target penetration, without damage, and for all field-made structural connections to be compatible with the design requirements.

To reach the design pile penetration and/or capacity the following techniques can be used:

- Driving
- Drilling
- Drilling to assist driving
- Drilling and grouting insert piles
- Drilling belled piles.

Unless otherwise indicated in the Particular Specification, drilling shall not be used for any other case.

3.1 Drilling to assist driving

If the required penetration cannot be reached by driving, the internal soil plug in some or all of the piles may be drilled out to a point no closer to the pile toe than 5 metres above the existing tip location, before the pile is re-driven down to the target penetration.

A cement grout plug shall be poured according to COMPANY requirements.

When calculating the grout plug length, no bond shall be assumed to act over the length of the pile wall formerly in contact with the soil.

3.2 Drilling for drilled and grouted insert piles

The two-staged drilled and grouted pile consists of two concentrically placed piles, making a composite section.

The first-stage pile (main casing pile) shall be driven to a penetration which has been predetermined:

- to be achievable with the available driving equipment
- to reach a level below which soils can hold an open hole with or without drilling mud
- to allow safety with respect to hydraulic fracturing if drilling is performed with mud.

Driving of the first-stage pile shall be in accordance with the General Specification [GS STR 431](#).

After driving the main pile at required penetration, or in case of early driving refusal, a hole shall be drilled below the main pile toe, using a bit at least 150 mm (6 inches) larger than the outside diameter of the insert pile to be installed.

Unless otherwise indicated in the Particular Specification, the use of an "under-reamer" with an expanding bit is prohibited in carbonate soils.

Drilling operations shall be done carefully to maintain proper hole alignment and to minimise the possibility of hole collapse. The drilling shall be performed with or without drilling mud to facilitate maintaining an open hole. If drilling mud is used, consideration shall be given to flushing the mud with circulating water upon completion of drilling. The drilling fluid shall be approved by COMPANY.

Drilling shall be stopped at the design penetration plus 1 meter. The drill cuttings shall be carefully cleaned up by air lifting.

The insert pile shall be carefully installed at 1 m above the drilling hole bottom, immediately after removal of the drilling gear. Grouting shall then begin according to COMPANY requirements.

Unless otherwise indicated in the Particular Specification the drilling and grouting shall be done as stipulated by [API RP 2A - WSD](#) section 12.5.8, and the computation of the allowable pile axial force for the drilled and grouted insert-piles shall be in accordance with the Section 7.4.4 of [API RP 2A - WSD](#).

3.3 Drilling for belled piles

Drilling can also be used if drilling of bells for belled piles is required.

The concrete mix used for belled piles shall be in accordance with Section 8.4.2 of API RP2A.

4. Procedures and equipment

4.1 Drilling equipment

The CONTRACTOR shall submit the following to the COMPANY:

- Detailed specifications and capabilities of the drilling equipment
- The infrastructure drawings for the drilling machine and calculations indicating the stresses in the pile, and possibly in the structures, induced by drilling. The pile integrity

under the effect of the drilling equipment dead-weight shall be explicitly stipulated for the worst case.

- The detailed drilling program, including the composition of the drilling mud (when used), the drilling method to be used (if drill flow is lost, etc.).
- The drill string diagram, including the position and spacing of the stabilisers.
- The drilling equipment mobilisation schedule to allow the equipment to be erected and tested sufficiently ahead of the beginning of works, if COMPANY judges this to be necessary.

4.2 Pumping and mixing equipment

Prior to the mobilisation, the following information shall be submitted to the COMPANY by the CONTRACTOR:

- The location of CONTRACTOR's and/or SUBCONTRACTOR's supply base, the storage area layout and availability, the relevant equipment to be used and details of access.
- Detailed specifications of the storage, mixing, pumping, generating, and testing equipment the CONTRACTOR intends to use together with the details of interconnecting pipe-work and any power supply requirements.
- Evidence that the mixing equipment is capable of mixing the grout components to the required quality and at the required rate.
- Evidence that the pumping equipment is capable to pump the grout through the piping system at the required density, rate and pressure.
- Proposed field manpower organisation and manning levels together with brief resumes of experience of supervising and quality control personnel.

5. Fabrication of drilled and grouted piles

5.1 Trial mix

Prior to the mobilisation, and at a date and location to be agreed with the COMPANY, the CONTRACTOR shall set up and operate as many representative items of grouting and testing equipment as specified by the COMPANY, up to the complete spread, and shall mix, pump, and test a trial mix witnessed by the COMPANY Representative.

The equipment shall be identical to that proposed for execution of the WORK. The materials used shall come from the same SUPPLIERS as the CONTRACTOR proposes to use for execution of the WORK.

The CONTRACTOR shall mix, pump, test and keep a minimum volume of slurry as indicated in the Particular Specification.

For each 1.6m³ (10 bbl) of slurry produced, the CONTRACTOR shall take a sample, cast and cure four cubes, and test them, in accordance with ASTM 109. The grout curing conditions shall simulate the actual field conditions, i.e. in sea water with appropriate salinity and temperature.

The four cubes from each sample will be tested at respectively 24 hours, 3 days, 7 days and 28 days age. The measured compressive strengths of each individual cube, as well the average values on all the cubes tested at the same age from all samples, shall be provided to COMPANY. If any measured compressive strength at 28 days age is below 17.25 MPa

(according to [API RP 2A](#) Section 8.4.1), the CONTRACTOR shall review the mix composition, mixing and testing equipment and procedure, and propose amendments. Furthermore the COMPANY may require further trial grout mix cubes to be tested.

The supervisory personnel shall be the personnel the CONTRACTOR proposes to employ offshore for supervision of the WORK.

If the performance of the equipment or personnel is not satisfactory, the COMPANY will require alternative solutions to be implemented.

5.2 Drilling

The drilling rig shall be installed on a platform, fixed either on the pile or on the jacket. Its operation shall depend as little as possible on weather conditions.

Drilling by means of a unit suspended from the derrick barge jib boom is prohibited.

The CONTRACTOR shall use stabilisers to ensure a proper alignment of the drilling string.

Monitoring of the drilling parameters shall be performed by the CONTRACTOR, including rate of progress, weight on bit, torque, and mud pressure (if any).

Holes for closely positioned piles shall not be open at the same time, unless there is assurance that this will not be detrimental to the pile capacity and that grout will not migrate during placement to an adjacent hole.

The CONTRACTOR shall supply sufficient experienced personnel to handle and control the drilling equipment, correct any machine failures, etc.

5.3 Grouting

Portland cement shall be high sulfate resistant ASTM C-150 Type V. Other high sulfate resistant cement can be used after COMPANY's approval.

The cement grout used shall be in accordance with the Section 8.4.1 of [API RP 2A](#).

The grout mix shall be made :

- with fresh water,
- in accordance with the Particular Specification. Cement shall not be stored in the open at sea. Any heavy aggregates (when used) shall be clean and free of clay.

Any water-reducing or plasticizing admixture that may be necessary to obtain the grout properties required for proper placement shall be submitted by the CONTRACTOR to the COMPANY for approval.

The grouting equipment shall be capable of maintaining a continuous grout flow until the entire annulus is filled.

The time before grouting the hole shall be minimised, in particular in soils which may be affected by exposure to sea water.

A representative number of specimens taken from random batches during grouting operations shall be tested to confirm that the design grout strength is achieved. The minimum number of grout specimens shall be as indicated in the Particular Specification, and the test procedure shall be in accordance with ASTM 109.

The specimens taken during grouting operations shall be subjected, until crushing test, to a curing regime representative of the actual field conditions, i.e. in sea water with appropriate salinity and temperature.

In addition to the grout strength, the grout density shall be controlled during grouting operations. For both above water and under water grouting, the grout density shall be controlled at both the pumping unit inlet and at the jacket outlet level. In particular for under water operations, such control means may include probing devices, which shall be submitted by the CONTRACTOR to the COMPANY for approval.

The grout quality shall also be tested at intervals during the grouting of each pile.

6. Reporting

For each pile installed, the following information shall be reported:

6.1 Main piles installed by driving

For the first-stage piles installed by driving, the required information to be recorded by the CONTRACTOR and provided to the COMPANY shall be in accordance with the General Specification **GS STR 431**.

6.2 Drilled and grouted insert piles

For the second-stage drilled and grouted insert piles, the following information shall be recorded by the CONTRACTOR and provided to the COMPANY for each pile:

- a) The pile number, jacket leg reference, and date.
- b) The type of drilling rig, and the drilling procedure used.
- c) The start and end penetration depth of drilling.
- e) The depth of penetration of the drilled and grouted insert pile.
- f) All relevant information on the drilling parameters, including the time spent for drilling each insert pile.
- g) The time lost due to bad weather or equipment failures, including the pile position at the time.
- h) The results of all grout cubes crushing tests.