

GENERAL SPECIFICATION

SURVEYS

GS EP GEO 701

Geotechnical Design Considerations for Soil-Pipeline Interaction

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07	11/2016	General review
06	05/2015	Organisation change - January 2015
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1. Scope

The purpose of this General Specification is to describe the requirements for geotechnical design considerations applicable to soil–pipeline interaction studies for submarine pipeline systems.

The soil–pipeline design requirements are applicable to all types of pipelines or flowlines, i.e.:

- Rigid pipelines, either laid on the seafloor or buried
- Flexible pipelines
- Umbilicals, power cables
- Risers, in particular at their touch-down and connection point with flowlines
- Spools and jumpers.

Foundation design of pipeline related seabed structures (e.g. ILT, FLET, crossing support or sleeper) is also addressed.

This General Specification does not cover seabed preparation before pipelay (e.g. dredging), nor trenching assessment required by the Project. Such requirements shall be sought in the Project Particular Specifications.

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

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

Therefore, this General Specification shall be read in conjunction with said documents and the other Company specifications and standards identified herein.

The reference lists given underneath only include general standards and professional documents where specific references have been made in this document. Unless otherwise stated in Company Project requirements or Particular Specifications, the latest revision shall apply for all documents.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published at the effective date of this document.

Reference	Title
API RP 2GEO	Geotechnical and Foundation Design Considerations
API RP 2N	Planning, Designing, and Constructing Structures and Pipelines for Arctic Conditions
Brinch-Hansen, J.	A revised and extended formula for bearing capacity, Bulletin No. 28, Danish Geotechnical Institute, Copenhagen (1970)

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Reference	Title
Cathie, D., Jaeck, C., Wintgens, J-F and Ballard, J-C	Pipeline geotechnics - State of the Art, <i>Int. Symp. Frontiers in Offshore Geotechnics</i> , Perth (2005)
DNV-RP-C207	Statistical Representation of Soil Data
DNV-RP-F109	On-bottom Stability of Submarine Pipelines
DNV-RP-F110	Global buckling of submarine pipelines structural design due to high temperature/high pressure
ISO 19901-4	Petroleum and natural gas industries Specific requirements for offshore structures - Part 4: Geotechnical and foundation design considerations
Lund, K.M.	Effect of increase in pipeline soil penetration from installation, OMAE 2000/PIPE-5047, ASME, February 2000
Oliphant, J. and Maconochie, A.	The axial resistance of buried and unburied pipelines, Proc. International Conference Offshore Site Investigation and Geotechnics Conference, London (2007)
Randolph, M.F. and White, D.J.	Pipeline Embedment in Deep Water: Processes and Quantitative Assessment, <i>Proc. Offshore Technology Conference</i> , OTC paper 19128, Houston, Tx, May 2008
SAFEBUCK JIP	SAFEBUCK JIP and DNV-RP-F110 Merged Guideline, August 2015 (2015)
Verley, R.L.P. and Sotberg, T.	A soil resistance model for pipelines placed on sandy soils. <i>Proc. Offshore Mechanics and Arctic Engineering Conf</i> , Vol V-A pipeline technology, pp. 123-131 (1992)

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Reference	Title
GS EP GEO 101	Offshore Geotechnical Survey
GS EP GEO 201	Offshore Geophysical Site Investigation
GS EP GEO 202	ROV Survey Work for the Installation and/or the Inspection of Offshore Structures and Flowlines
GS EP PLR 100	Submarine pipeline systems
GS EP SPS 034	Well Jumper Design
GS EP SPS 038	Subsea Structures design & fabrication

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3. Abbreviations

AUV	Autonomous Underwater Vehicle
BE/HE/LE	Best/High/Low Estimate
CPTU	Cone Penetration Test with Pore Pressure Measurement
DSM	Digital Surface Model
FLET	Flowline End Termination
ILT	In-Line Tee
TOP	Top Of Pipe
VHR/UHR	Very/Ultra High Resolution

4. Site and soil investigation requirements

4.1 General

The site and soil investigation procedures and equipments shall be in agreement with the:

- **GS EP GEO 201** for geophysical site surveys
- **GS EP GEO 101** for geotechnical surveys.

Unless site geotechnical data are already available, the performance of a geophysical survey alone, or in addition to a desk study, is not sufficient for detailed engineering purposes.

The scope of work and extent of site and soil investigation shall depend on the soil type and strength, as well as on the soil variability along the planned pipeline route. As a guideline, the following basic soil parameters shall be determined as a minimum:

- In clayey (cohesive) type of soils: grain size distribution, Atterberg plastic/liquid limits, in situ water content and unit weight, intact and remoulded undrained shear strength, friction angle at low effective stress.
- In sandy (cohesionless) type of soils: grain size distribution, minimum/maximum density and estimated in situ relative density, unit weight and friction angles of peak and residual shearing resistances.

More specific equipment and procedures shall be required for:

- Uneven seafloor topography with outcrops and depressions
- High slope gradients with potential slope instability
- Very soft sediments generally encountered in swamp areas or deep water sites
- Specific areas, such as carbonate soils with highly variable cementation degree, intermediates soils (such as silts), seismically active areas, or (past or present) arctic conditions with possible iceberg scars and boulders
- Shore approach and landfall areas.

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4.2 Specific requirements related to soil–pipeline interaction

Specific requirements related to the shallow depth of interest for soil–pipeline interaction studies (e.g. top 1 to 3 metres of sediments for surface-laid pipeline) comprise:

- Survey of seafloor features and topography, by means of swathe bathymetry and side scan sonar
- High resolution sub-bottom profiling of uppermost 20 m of sediments
- Sampling of top 0.5–2 m of seafloor and seabed soils, by means of e.g. box coring or high quality piston sampling for soft clayey soils.

Depending on Project requirements, complementary survey tools shall be considered with the objective to focus on shallow strata definition, including:

- For geophysical surveys at shallow water sites, use of towed resistivity and refraction seismic methods
- For geophysical surveys at deep water sites, use of very high resolution (VHR) to ultra-high resolution (UHR) seismic methods by use of AUV surveys
- For geotechnical surveys, performance of in situ CPTU tests allowing a quick representation of soil variability along the pipeline route
- For geotechnical surveys in soft clays,
 - Performance in situ CPTU tests with larger cone area, e.g. 15 cm² instead of the standard 10 cm², for increased accuracy
 - Performance of specific tests for determining the remoulded strength and clay sensitivity, such as cyclic T-bar, Ball or Vane tests
 - Performance of small-scale in situ tests in box core samples, such as mini T-bar or ball testing.

The performance of dedicated soil-pipeline testing shall be considered in advance of pipeline design. These can comprise soil-pipeline planar interface shear testing, centrifuge model testing and large scale soil-pipeline testing on a laboratory seabed or in situ. These tests shall allow soils to be consolidated, be representative of the actual stress conditions at soil-pipeline interface, with adaptable shearing speed in order to evaluate (fast) undrained to (slow) drained shear strength. Pipeline interface shall be representative of actual surface finish. No laboratory testing standard exists for these tests and expert geotechnical engineering is required for defining and interpreting them. The proposed procedure shall be submitted to Company for approval.

When required, integration of the geophysical and geotechnical survey data shall be performed by suitably qualified personnel, with the objective to avoid misleading interpolation between individual sample and/or in-situ test locations.

Depending on Project requirements, reporting of a pipeline route site and soil investigation shall address some more specific issues, such as:

- Seafloor contour lines and slope gradient, in particular for reducing the number and consequences of possible free-spanning