

GENERAL SPECIFICATION

GEOMATICS

GS EP POS 002

Subsea positioning works

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1. Scope

The objective of this specification is to provide reliable three-dimensional underwater positioning for operations conducted by Contractor, in compliance with Company requirements.

This specification is to be used in conjunction with the other documents referred to in section 2, especially with Company specification for the offshore surface positioning works.

2. Reference documents

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

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
ISO/TS 29001	Petroleum, petrochemical and natural gas industries – Sector-specific quality management systems - Requirements for product and service supply organizations
OGP P1/11	Geophysical position data exchange format
OGP P2/11	Positioning data exchange format

Total General Specifications

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

Reference	Title
GS EP POS 001	Offshore surface positioning works
GS EP POS 003	Land surveying and positioning works
GS EP POS 004	The use of Differential Global Navigation Satellite System
GS EP GEO 401	GIS requirements for engineering site surveys and studies
GS EP GEO 402	GIS Requirements for Field Development Project

3. Scope of work

Contractor shall carry out all subsurface positioning tasks of the project on a highly professional manner, in accordance with industry standard, current surveying practice and to the satisfaction of the Company.

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3.1 Subsurface positioning systems

The Contractor shall supply equipment with full back-up, unless otherwise specified.

The subsea positioning systems selected by Contractor, shall allow providing a position of the subsea mobile continuously during the required period of time and within the required accuracy (defined as corresponding to a 95% confidence level) anywhere in the project area of operations.

2-Sigma accuracy (86% confidence level) currently quoted for USBL (ultra short base line) systems itself shall be better than 0.5% slant range to be combined with surface positioning accuracy, VRU (vertical reference unit), gyro and SV (sound velocity) impact on horizontal accuracy.

2-Sigma accuracy (95% confidence level) currently quoted for LBL (long base line) systems shall be better than 0.3 m with range measurement better than 0.1 m - Wide band based systems.

Positioning acoustic transducers shall be installed such that shadowing, reflections and noise level are minimised, and that there is no interference from other transmitters. All offsets to and from reference points on the vessel (including the heights) shall be physically determined by acceptable survey methods.

Contractor shall measure and validate all antenna/sensors offsets at mobilization stage, after each modification or at any other time on the request of the Company representative. All offsets and any offset change shall be logged in a specific offset table and diagram using standard forms. For subsea structure and large floating unit, offsets shall be derived from yard dimensional control.

3.2 Surface positioning

All surface positioning systems shall fully comply with **GS EP POS 001**.

Both surface and subsurface systems shall be integrated to the main survey computer in order to provide the most accurate and reliable absolute positioning solution.

3.3 Acoustic positioning systems

Acoustic positioning systems shall be used for all subsea positioning operations.

Contractor shall supply underwater positioning systems with associated computer and state of the art software.

Depending on the vessel and on the tasks to be performed, it may be:

- USBL acoustic positioning system working in MF or LF band
- A LBL acoustic positioning system working in the LF (low frequency), MF (medium frequency) or EHF (extra high frequency) band
- A combination of USBL and LBL systems known as L/USBL
- Other systems, available on the market, such as SBL (short base line), so-called "underwater-GNSS", sparse LBL and INS (inertial navigation system) based acoustic systems

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Note: Systems such as L/USBL or MuLBL may be used for specific static operations (rig station keeping, well spud-in, etc...).

3.3.1 Ultra Short Base Line (USBL) system

USBL systems shall be operated from surface vessels in order to monitor relative position to a fixed structure on the seabed or to track position and depth of subsea mobiles. Most of the time USBL data shall be combined with surface positioning system.

When USBL system is part of the DP (dynamic positioning) system references, integrated navigation system shall be directly interfaced to USBL system, avoiding any intervention on the DP system.

A particular care shall be taken in order to mitigate the risk of acoustic interferences with other systems.

This subsurface positioning system shall be integrated with the online computer system to provide an accurate and reliable absolute position.

The Contractor shall supply survey-grade complementary equipment in order to have a fully operational USBL system interfaced to the integrated navigation system and coupled to the surface positioning systems.

Equipment set-up shall comply with manufacturer guidelines and procedure, and a special attention shall be given to the following:

- Systems routine maintenance shall have been performed by manufacturer within the last 12 months prior to field mobilization. Maintenance service report shall be submitted to Company for review
- Calibrated acoustic positioning system shall provide accuracy better than 0.5% of the slant range (2 sigmas)
- The hull mounted USBL transducer shall be located such as to minimise disturbances from thrusters and machinery noise and/or air bubbles
- Transducers shall be installed on-board the vessels according to manufacturer guidelines and Contractor mobilization procedure. A lay-out sketch of all the acoustic transducers shall be issued including 3-D offset with reference to vessel CRP (common reference point)
- The USBL equipment shall be supplied with its own computer and console, capable of operating as a stand-alone system
- The VRU shall be of a survey grade equipment recommended by the USBL manufacturer and installed following manufacturer guidelines
- The system shall be capable of positioning at least nine transponders and/or responders

3.3.2 Long Base Line (LBL) system

The LBL system shall be used to perform accurate surface positioning of drilling units (vessels, rigs) and very accurate subsea positioning using transponder arrays deployed on the seabed.

In case of use of acoustic technique for metrology operations, high accuracy LBL system (MF, MF wide band or EHF) shall be used.

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After the deployment, the array shall be adjusted by performing a relative or absolute calibration.

The LBL transponders shall be of the latest generation. As a base case, over 75% of transponders deployed on every array and sub-array shall be fitted with SV sensors. Depending of environmental conditions on operation area, this percentage could be raised if deemed necessary by Company and fitted with digiquartz.

Transponders of the array may be deployed:

- With a flotation collar and a dead-weight
- In a stand or frame bucket
- In a structure bucket

3.3.3 LBL navigation software

State of the art LBL navigation software shall be mobilised for operation.

It will be built either of one or more modules embedded in the navigation system, or a full separate software package interfaced to the integrated navigation system.

In both cases, the system shall include full comprehensive, online quality control functions.

System shall have the following features:

- Full documented user manual
- Database to store SV profiles, coordinates and depth of transponders, various results
- Combined scale factor (including depth) calculation and display, calibration
- Ranges acquisitions with online quality control of range acquisition
- Least square array adjustment able to work with more than 150 nodes, and providing both results and statistical quality criteria
- Box-in navigation and calculation including full reporting capabilities
- LBL navigation with all quality criteria, graphic display, etc...

In addition, Contractor shall mobilise and use extensively as a redundant calculation an adjustment tool dedicated QC software package from the market, agreed by Company, in order to confirm partial and global adjustments, all box-in and positioning quality evaluation results.

3.3.4 Underwater GNSS (nasnet, mini nasnet, GIB buoys)

Underwater GNSS systems shall be used to perform accurate positioning for ROV (remote operated vehicle) or AUV (autonomous underwater vehicle) using a surface buoys network or a subsea acoustic array. A minimum of 5 references shall be deployed. This system may be used in replacement of USBL system.

In case of a surface buoys network, each buoy shall be equipped with DGNSS or RGNSS and pingers. Contractor shall follow the guidelines provided in [GS EP POS 004](#).

In case of a subsea acoustic array, the transponders may be deployed:

- With a flotation collar and a dead-weight

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- In a stand or frame bucket
- In a structure bucket

After the deployment, the array shall be adjusted by performing a relative or absolute calibration.

The beacons shall be of the latest generation. As a base case, over 75% of beacons deployed on every array shall be fitted with environmental sensors. Depending of environmental conditions on operation area, this percentage could be raised if deemed necessary by Company.

3.3.5 Doppler Velocity Log (DVL) based

DVL is used as an extra equipment to aid navigate ROVs or AUVs and to increase positioning accuracy. The DVL bounces sound off the bottom and can determine the velocity of mobile unit moving above the sea bed.

3.3.6 Inertial systems based

The INS shall be used as an extra equipment to perform accurate underwater positioning for ROV and AUV. High accuracy INS may also be used for metrology operations.

3.4 Complementary Parameters

In order to monitor the complementary parameters to be used in association with underwater positioning, various additional equipments shall be used in association such as survey grade gyrocompass, VRU , SV profiler, CTD (conductivity-temperature-depth) probes, subsea transponders with optional sensors (depth, dual axis inclinometer, SV).

3.4.1 Orientation/Heading

Orientation of subsea units shall be derived from survey-grade gyrocompass (north-seeking, fiber optic or INS-based gyrocompass). Recent bench calibration certificate shall be provided and alignment error shall be calculated prior to operation using commonly approved survey techniques.

Alignment errors shall be checked daily or prior to each dive, using commonly approved survey techniques.

Both surface and subsea gyrocompass shall be interfaced to navigation system and monitored in real-time.

Accuracy of surface and subsea equipment (typically better than 0.1 deg) shall be documented in survey procedures and approved by Company prior to the mobilization.

3.4.2 Pitch & roll

All USBL, SBL and surface position information shall be adjusted after application of pitch & roll errors.

Pitch & roll of the surface unit, shall be monitored in real-time, using a fully calibrated survey-grade VRU with high data output rate (typically 1Hz or greater). The accuracy of the equipment (strictly better than 0.05 deg), shall be documented in survey procedures and approved by Company prior to mobilization. Specifications and calibration certificate shall be provided at

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mobilization stage and mis-alignment shall be calculated using commonly approved survey technique.

Corrections due to pitch & roll shall be calculated in real-time by navigation system.

3.4.3 Environmental parameters

Contractor shall regularly update water column and sea bed parameters, depending on the stability of these parameters, prior to each operation, at least daily and at any time, upon request of the Company representative.

3.4.3.1 Sound Velocity (SV)

The SV shall be considered as a fundamental parameter in achieving subsurface positioning accuracy.

It is the responsibility of Contractor to ensure that accurate information is collected, checked and applied.

SV shall be measured using SV sensors. There are two main instruments used to measure the velocity of sound in water:

- The SV profiler which directly measures the time taken to transmit an acoustic signal over a known baseline of the order of a few decimetres, and calculates therefore directly the local SV.
- The CTD probe which has sensors to measure CTD. From this data, the SV may be derived through empirical formula.

SV derived from SV probe shall be used as primary method whereas SV derived from CTD sensors readings, shall be only used for low accuracy operations or as a contingency method.

The performance of the equipment (accuracy typically better than 0.05 m/s), shall be documented in survey procedures and approved by Company prior to the mobilization. Specifications and calibration certificate shall be provided at mobilization stage. Calibration certificates shall comply with validity period as per manufacturer's recommendation. The certificate shall be valid until the completion of the operation.

The serial number shall be clearly indicated to ensure the correct coefficients are applied. Only calibrated equipment shall be used.

SV being a function of temperature, salinity and density which show temporal and spatial variations therefore regular update of velocity measurements are required:

- Full water column profile measurement shall be performed on a daily basis on the deepest location of each work area
- A SV measurement shall be performed before each key stage of acoustic measurements. The bottom velocity shall be used for the baseline measurements and monitored before, during and at the end of the baseline collection

In addition, for LBL positioning a full water column profile measurement shall be performed immediately prior to the start of box-in procedure. The positioning software shall be able to store the full column velocity profile in order to interpolate data as required. Extrapolation of SV profile is not being agreed. For LBL work, SV profile shall be used for ray-bending and range study.

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Contractor shall provide full back-up for SV profiler.

For LBL array installation and calibration, all SV sensors (SV end cap on beacons, probe and CTD) shall be compared at the beginning of the operations in order to detect any discrepancy in the homogeneity and consistency in SV measurements.

3.4.3.2 Depth measurement

All depth shall be measured using digiquartz pressure sensors providing highest accuracy and reliability performance (paroscientific, valeport or similar). In this case, a surface barograph shall be used for atmospheric pressure corrections. Model/type shall be adjusted to the working water depth.

The performance of the equipment shall be documented in survey procedures and approved by Company prior to the mobilization. Specifications and calibration certificate shall be provided at mobilization stage. Calibration certificates shall comply with validity period as per manufacturer's recommendation. The certificate shall be valid until the completion of the operation.

The serial number shall be clearly indicated to ensure the correct coefficients are applied. Only calibrated equipment shall be used.

Contractor shall provide this equipment with full back-up.

The pressure to depth conversion shall strictly follow the following steps:

1. Zero offset/or zero bias observation (instrument pressure – barometric pressure)
2. Pressure to depth conversion using:

$$Depth = \frac{\text{Observed digiquartz pressure} - (\text{Barometric Pressure} + \text{Offset})}{\text{Mean Density} * \text{Local Gravity}} * 1000$$

Where:

Air pressure is expressed in mbar,

Mean water density is calculated from full water column CTD profile and expressed in g/cm³,

And local gravity expressed in m/s²

1. Tidal reduction using observed or predicted tide to the project vertical datum.

At the start of the campaign, all pressure sensors (including spares) shall be tested simultaneously during a test dive in order to identify relative instrument offset.

3.5 Acoustic frequency interference

In all case, Contractor shall analyse the possible interferences of the systems it will operate and other systems used by other. Contractor shall investigate compatibility between all underwater positioning systems and propose solutions (acoustic frequency management plan or other) in order to mitigate possible interferences between its vessels and other units working in the area.

In the case of large field development involving several surface unit, all potential acoustic interference between drilling vessels, surface construction and support vessels, barges together

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with their associated ROV and sub-sea tools and equipment shall be identified in the procedure and a proper acoustic frequency allocation plan shall be proposed to Company, for further analysis.

The selection of the acoustic systems to be used during operations shall be made having in mind this problem of acoustic interferences.

Acoustic frequency management plan shall be issued for information to Company. Company shall issue an official frequency management plan including all frequency allocation for each individual surface unit before the start of the operations.

Company shall be responsible of decision for Compatible Operations (COMOPS) and Simultaneous Operations (SIMOPS).

3.6 Underwater positioning reference array

For large field development project in deep water, at Company request, Contractor shall design, deploy and calibrate a global underwater positioning reference array, built of permanent stands or frames, and able to be populated with various kind of acoustic transponders or pingers, in order to insure a geographical subsurface homogeneity of coordinates as well as a good repeatability over the time.

Reference array shall be designed in order to provide a global LBL coverage of the field. It will be available for all users during the development and the field life (drilling, installation, IMR, seismic acquisition).

Design of the array and of the stands/frames as well as the proposed calibration method statement shall be submitted to Company at the earliest stage of the project.

This common underwater positioning reference array will have the following advantages:

- All structures relative and absolute positions shall be known with the same level of accuracy as referenced in a coherent system. In particular the interface between drilling Contractor and subsea Contractor which work in parallel will be made easier
- The calibration and adjustment of the global array will allow obtaining the highest level of accuracy - typically sub-metric accuracy (better than 0.5 m at 2 sigmas)
- Once calibrated, the reference array shall be used, all along the field life without any additional calibration work
- This array may be able to be extended in order to cover further developments or acquisitions, with the same level of accuracy

3.6.1 Array requirements

The array shall be designed in order to provide a global coverage of the field area where sub-metric underwater positioning is required for the following activities:

- Flowline & umbilical Installation
- Development drilling
- Subsea structures installation
- Inspection and maintenance activities