



Exploration & Production

GENERAL SPECIFICATION

GEOMATICS

GS EP POS 002

Subsea Positioning Works

01	01/2011	General standards Update
00	10/2009	First issue (equivalent to former GS EP GEO 302 and GS EP SUG 002)
Rev.	Date	Notes

Owner: EP/GSR

Managing entity: EP/GSR



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1. Scope

The objective of this Specification is to ensure that the subsurface positioning requirements of Company during offshore operations are met.

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.

This Specification is designed to be complementary to the project Scope of Work which outlines the nature and the requirements of the entire project.

Additionally the objective of this Specification is to provide reliable three-dimensional underwater positioning for operations conducted by Contractor, for Field development activities including Subsea structure positioning, drilling operations or ROV Inspection & Survey tracking.

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.

All documents referred to in this section shall be considered as the latest versions and it shall be Contractor responsibility to ensure that Contractor is in possession of these particular documents and that any qualifications are valid.

Standards

Reference	Title
ISO/TS 29001 : 2010	Quality management system requirements for the design, development, production, installation and service of products for the petroleum, petrochemical and natural gas industries, based on ISO 9001:2010

Professional Documents

Reference	Title
UKOOA Guidelines	Guidelines for the Measurement of Quality and Basic Quality Control of Offshore Positioning Data published by the UKOOA Survey and Positioning Committee, June 1992
UKOOA Guidelines	Guidelines for the use of DGPS for offshore positioning published by the UKOOA surveying and positioning committee in 1994
UKOOA P2/94	Recommended format for recording of raw offshore navigation data which is an extension of the existing P2/91 format with additional records for raw GPS data and associated pseudo-range corrections



Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS EP STR 403	Acceptable criteria of a support vessel for offshore works
GS EP POS 001	Offshore surface positioning works

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.

Contractor shall carry-out all subsurface positioning tasks with fully qualified personnel and state of the art equipment, fully calibrated and in perfect working order. Contractor shall retain its equipment and personnel for the exclusive use of Company for the duration of the positioning operations.

Contractor shall ensure that all specified underwater navigation and subsurface positioning equipment including computer hardware and software are installed, calibrated and operational. The positioning work shall only commence with all systems fully calibrated and properly functioning.

The Contractor shall supply the underwater positioning systems, providing the required information with sufficient redundancy and quality control output, in order to ensure that positioning is within the required accuracy.

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

When applicable, 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.

Subsea positioning includes the following systems:

- Ultra Short Base Line (USBL) acoustic positioning system usually combined with Surface positioning
- Short Base Line (SBL) acoustic positioning system, usually combined with Surface positioning
- Long Base Line (LBL) acoustic positioning system using Low, Medium Frequency or Extra High Frequency, usually related to local geodetic reference system
- Combined acoustic positioning system with Integrated Navigation System (INS), Doppler Velocity Log (DVL), sparse LBL technique.
- Combined LBL and USBL (LUSBL) acoustic positioning system, integrated with Surface positioning
- Underwater GPS based on LBL principle.

Performance and accuracy are the main selection criteria.

The highest standard of accuracy shall be obtained with LBL acoustic system working with associated transponders and acoustic telemetry, while the lowest accuracy will be obtained with the USBL acoustic system.

Additional equipment may be proposed by Contractor in order to improve the standard performance of the different acoustic systems, big head, Doppler, inertial navigation, Kalman filtering, etc.

Contractor may propose any other equipment, even if not specified herein, which is proven as fully operational, and satisfies Company specifications.

The Subsea positioning system 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 (95% confidence level) currently quoted for USBL systems itself is better than 0.5% water depth to be combined with surface positioning accuracy, VRU, Gyro and SV impact on horizontal accuracy.

2-Sigma accuracy currently quoted for LBL systems is better than 0.3 m with range measurement better than 0.1 m - Wide Band based systems.

Subsea accuracy budget calculation shall be included in survey procedure and subject to Company approval. Reference values shall be the one quoted by Manufacturer. All sources of errors shall be identified and mitigated in order to provide the best position solutions.

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 mobilisation 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.



All raw data will be time tagged to GPS or UTC time, logged in a format and stored on medium agreed by Company.

All necessary spare parts and back-up, all user, operation and maintenance manuals shall be available onboard the vessel at mobilisation stage.

3.1 Geodetic System

The Project Geodetic system to be used shall be specified by Company by means of an official Company geodetic system data sheet including an example of coordinates transformation.

All geodetic data, spheroid and projection parameters, datum shift values shall be input in the navigation system, verified and submitted for approval of the Company representative before the start of the operation

Transformation from WGS-84 to local datum shall be tested, using a set of coordinates provided by Company.

For LBL positioning work in deep water, both Scale factor and elevation factors shall be calculated for the specific Project geodetic system.

3.2 Surface Positioning

All Surface positioning systems shall fully comply with the Company general specification **GS EP POS 001**.

Each time a high level of accuracy is required (deep water, LBL work, Subsea structure installation, etc.) Contractor shall propose surface positioning system offering sub metric accuracy.

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 or L/USBL acoustic positioning system working in MF or LF band
- A LBL acoustic positioning system working in the low frequency (LF) medium frequency (MF) or extra high frequency (EHF) band
- A combination of USBL and LBL systems known as L/USBL
- Other systems, available on the market, such as SBL, so-called "Underwater-GPS", sparse LBL and Inertial Navigation (INS) based Acoustic systems.

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 USBL

USBL systems shall be operated from surface vessels in order to monitor relative position to a fixed structure 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 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. Frequency allocation plan shall be strictly applied (when applicable) according to section 13 Underwater Acoustic Normalisation.

3.3.2 LBL

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.

High accuracy LBL system (MF, MF wide band or EHF) shall be used for metrology operations.

When required, LF (low frequency) LBL systems shall be considered for long range LBL work or in order to avoid interferences.

3.3.3 Other systems

Various systems may be used:

- Underwater-GPS: Nasnet, mini-Nasnet, GIB buoys
- Doppler Velocity Log (DVL) based, enhancement method for USBL or SBL positioning
- Inertial systems based, enhancement method for USBL or SBL positioning.

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, Vertical Reference Unit, Sound velocity profiler, Conductivity-Temperature-Depth probes, subsea transponders with optional sensors (depth, dual axis inclinometer, sound velocity).

See details in section 11.

3.4.1 Orientation/Heading

Orientation of surface unit shall be derived from Survey-grade gyrocompass (North-seeking, Fiber Optic Gyro, or GPS-Based gyrocompass). Recent Bench calibration certificate shall be provided.

Orientation of Subsea unit shall be derived from Survey-grade subsea gyrocompass (North-seeking, Fiber Optic Gyrocompass, etc.). Recent Bench calibration certificate shall be provided.

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 mobilisation.

3.4.2 Pitch & Roll

All USBL, SBL and Surface position information shall be corrected from pitch& roll errors.

Pitch & roll of the surface unit, shall be monitored in real-time, using a fully calibrated survey-grade VRU. The accuracy of the equipment shall be strictly better than 0.05 deg. Recent Bench



calibration certificate shall be provided. Corrections due to Pitch & roll shall be calculated in real-time by navigation system.

3.4.3 Water column parameters

Contractor shall regularly update water column 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)

Sound Velocity shall be considered as a fundamental parameter in achieving subsurface positioning accuracy.

Sound Velocity shall be measured using Sound Velocity sensors. Whereas, SV derived from CTD sensors readings, shall be only used for low accuracy operations or as a contingency method. When SV and CTD sensors are both available for operation, they will possibly be simultaneously logged and compared on regular intervals, in order to assess each other performance stability.

The performance of the equipment (accuracy typically better than 0.05 m/s), shall be documented in Survey procedures. Specifications and calibration certificate shall be provided at mobilization stage.

Contractor shall provide full back-up for SV profiler.

3.4.3.2 CTD Profile

CTD sensors shall be required in order to perform water density calculation to be used for pressure to depth conversion. CTD sensors may be used for Sound Velocity calculation only for low accuracy operations and as a contingency method.

Performance of the equipment shall be documented in Survey procedures and approved by Company prior to the mobilisation. Specifications and calibration certificates shall be provided at mobilisation stage.

Contractor shall provide this equipment with full back-up.

3.4.3.3 Depth Measurement

All depth shall be measured using Digiquartz pressure sensors. In this case, surface barograph shall be used for atmospheric pressure corrections.

Performance of the equipment shall be documented in Survey procedures and approved by Company prior to the mobilisation. Specifications and calibration certificate shall be provided at mobilisation stage.

Contractor shall provide this equipment with full back-up.

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 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 will issue an official Frequency Management Plan including all frequency allocation for each individual surface unit before the start of the operations.

Company will be responsible of decision for Compatible operations (COMOPS) and Simultaneous operations (SIMOPS).

See details in section 13.

3.6 Underwater Positioning Reference Array

For large Field development project in deep water, 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 co-ordinates as well as a good repeatability over the time.

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

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 and shall conform to section 12 detailed specifications.

3.7 Integrated Navigation System

Both surface and subsurface systems and survey sensors shall be interfaced to the integrated Survey and Navigation system. This system shall offer full comprehensive online quality control features in order to provide the most accurate and reliable surface and subsurface position solutions.

The minimum configuration shall include the navigation software package, computer and spare, uninterruptible power supplies (UPS), screens, printers, interfaces, storage capabilities and all cables and accessories necessary to provide a full time positioning, navigation and quality control service. Full Back up shall be provided.

A functional diagram of the system shall be included in the Positioning & Survey procedure.

3.8 LBL Calibration and Navigation software

LBL Navigation software shall be either one or more modules embedded in the Navigation system, or a full separate software package interfaced to the integrated Navigation system.

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

A separate dedicated QC software package shall be used in order to confirm all adjustments, box-in and positioning quality evaluation results.

3.9 ROV Interfacing

USBL system shall be interfaced to the ROV telemetry system, in order to be able to work in responder mode.

LBL system shall be interfaced to the ROV telemetry system, in order to be able to work with a Subsea transducer.

Navigation system shall be interfaced to the ROV telemetry system, in order to acquire in real time, underwater gyrocompass, bathy-system, SV sensors and other additional ROV operated sensors.

3.10 Subsea Structure orientation and attitude

Subsea structure orientation shall be measured using an underwater north-seeking gyrocompass, which shall be included in the ROV spread.

Subsea structure attitude shall be derived from pitch and roll sensors, preferably integrated with the subsea gyrocompass or acoustic transponders.

ROV Gyrocompass shall be interfaced to the main survey computer. Otherwise, orientation may be derived from LBL measurement.

Interface frames or docking devices between gyrocompass (or/and ROV) and structures shall be carefully calibrated in order to achieve the required level of accuracy.

The calibration of the gyrocompass and of the frame (or/and docking devices) shall be carried out during the harbour mobilization, using land survey techniques.

The calibration of the structure receptacle (on anchors, ILT, FLET, and SPS) shall take place at the construction yard, using land survey techniques.

3.11 Subsea Metrology

Subsea metrology shall be performed in order to determine the precise configuration of spool pieces between FLETs or well jumpers between FLET, ILT, manifolds and wellheads.

Various methods may be used based on taut wire, acoustic or inertial systems. A combination of 2 of these systems may be selected in order to improve accuracy and redundancy of metrology measurements.

Parameters to be measured are:

- Horizontal Range between centre of the flanges/hubs
- Relative orientation of the flanges/hubs
- Relative height of the flanges/hubs
- Attitude of each flange/hub
- Height above the seabed.

A detailed survey of the seabed along the tentative route of the jumper/spool piece or the well jumper shall be carried out. Results of the survey may be integrated in a Digital Terrain Model in order to investigate possible interferences between seabed and spool/jumper.

This survey shall be carried out with ROV equipped with calibrated bathy-system and using high accuracy positioning.



Dimensional control of the ROV mechanical interface shall be carried out during the harbour mobilization, using land survey techniques or during preliminary trials.

Dimensional control of the structure receptacle (on anchors, ILT, FLET, and SPS) shall be carried out at the construction yard, using land survey techniques.

3.12 Calibration and Control

The calibration of all positioning systems and sensors is strictly the responsibility of Contractor.

Calibration procedures shall be issued and documented as per the Quality System statements and will be submitted to Company for approval.

Each calibration shall be carried out using a technique suitable to the corresponding equipment and conforming to Manufacturer's instructions. Contractor shall strictly follow procedures which have been approved by Company. Contractor shall immediately inform Company for any deviation in procedures. In such case, new procedure shall be submitted.

All calibrations shall be carried out by qualified staff and witnessed by a Company Representative.

A report on the calibrations, together with all observations and calculations, carried out at mobilisation shall be completed and submitted to Company for approval before the start of the operation.

No uncalibrated equipment or equipment components shall be used during operations.

At Company request, any sensor or system used during the operation shall be either checked, or post calibrated at the demobilisation of the vessel using the same procedures as used at her mobilisation.

3.12.1 General

All sensors calibration sheets shall be provided at mobilisation stage.

All equipment shall be systematically calibrated at the start of the operation and in particular:

- DGPS shall be health checked against a shore reference by land survey techniques
- Survey Gyrocompasses shall be calibrated against a shore reference geodetic point using land survey techniques
- Vessel and underwater Gyrocompasses shall be calibrated against calibrated survey gyrocompass or against a shore reference geodetic point using land survey techniques
- VRU used for positioning purpose shall be calibrated against a high accuracy inclinometer and C-O calculated by land survey techniques
- USBL systems shall be fully calibrated immediately upon arrival on site
- SV/CTD sensors shall be cross-checked upon arrival on site.

All calibrations and controls shall be carried out by qualified staff and witnessed by a Company representative.

Certificates of calibration of equipment manufacturers shall not be older than one year (Gyrocompass, underwater gyrocompass, etc.) and not older than 6 months for critical equipment (SV profiler, Inclinometer, CTD probes, bathy-systems). For metrology purpose, equipment shall be calibrated immediately prior to the mobilisation.

Contractor shall submit to Company their own calibration procedures for approval. He shall strictly follow them. These procedures shall be in accordance with Manufacturer's calibration procedures and guidelines.

Calibration procedures shall be referenced in the Positioning and Survey mobilisation procedures, calibration certificates of equipment manufacturers shall be included in the dedicated Positioning and Survey mobilisation report.

3.12.2 Calibration and control to be performed at the mobilisation harbour

- All Vessel/ROV offset shall be checked
- All DGPS systems including DGPS interfaced to DP System
- All Vessel gyrocompasses if interfaced to DP System
- All Vessel VRU if interfaced to DP System Acoustic reference
- ROV gyro/inclinometers including interface frames (and/or docking devices)
- Metrology equipment including mechanical interfaces.

All these controls shall be performed using approved survey techniques.

3.12.3 Dimensional Control to be performed at the construction yard

Mechanical interfaces with the metrology equipment and ROV interface frames (and/or docking devices) for anchors, ILT, FLET, and SPS.

All these controls must be performed using land survey techniques.

3.12.4 Calibration and control to be performed on site

For all Survey and Construction vessels, a general check of all positioning systems shall be performed immediately prior to the start of the operations, including cross check of DGPS systems, gyrocompass and VRU calibration. A full USBL calibration shall be carried out and the results shall be submitted to Company for approval.

For Construction Vessels, when a recent (less than a month) calibration has been performed by a Manufacturer technician, Contractor shall submit a fully documented calibration report for Company approval.

In case of approval, Contractor will carry-out a confirmation check of the USBL systems against a reference structure located on the seabed (subsea structure, a frame of the calibrated reference array).

A method shall be proposed by Contractor and approved by Company ("Spin" procedure on top of a seabed reference is not agreed). Results shall be strictly within the expected accuracy otherwise a full calibration of the USBL shall be required.

4. Reference parameters

4.1 Table of Tolerance and accuracy

Accuracy quoted corresponds to 95% confidence level (or 2-Sigma one dimension accuracy).

Installation tolerances given are considered as typical. They shall be in accordance with relevant Company's construction specification.



Exploration & Production

General Specification

Date: 11/2010

GS EP POS 002

Rev: 01

TYPICAL SUMMARY OF TOLERANCE/ MEASUREMENT ACCURACY

FIELD DEVELOPMENT PROJECT

ITEM	DESCRIPTION	INSTALLATION TOLERANCE (+/-)	AS-BUILT ACCURACY	A	PROPOSED METHODS	ACCURACY		
1	FLOWLINES	CORRIDOR	15	HORIZONTAL	5	DGPS1+HIPAP USBL	0.5% WD	
2	FLOWLINES 2000M FPSO/FPU	CORRIDOR	5	HORIZONTAL	2.5	MF LBL	0.3m	
3	FLET	CUT-TO-LENGTH	5	CUT-TO-LENGTH	1	MF LBL	0.3m	
		LATERAL	2.5	LATERAL	1	MF LBL	0.3m	
		ATTITUDE	2.5	ATTITUDE	0.5	2 AXIS INCLINOMETRE	0.01deg	
		ORIENTATION	1	ORIENTATION	0.5	ROV GYROCOMPASS	0.2deg	
4	ILT	LONGITUDINAL	5	LONGITUDINAL	1	MF LBL	0.3m	
		LATERAL	2.5	LATERAL	1	MF LBL	0.3m	
		ATTITUDE	2.5	ATTITUDE	0.5	2 AXIS INCLINOMETRE	0.01m	
		ORIENTATION	1	ORIENTATION	0.5	ROV GYROCOMPASS	0.2deg	
5	FLOWLINE 500 M FIXED STRUCTURE	CORRIDOR	5	HORIZONTAL	2.5	DGPS1+HIPAP USBL	0.5% WD	
6	RISERS	TDP	5	HORIZONTAL	1	MF LBL	0.3m	
7	MANIFOLDS	HORIZONTAL	2.5	HORIZONTAL	1	MF LBL	0.3m	
		ATTITUDE	1	ATTITUDE	0.5	2 AXIS INCLINOMETRE	0.01deg	
		ORIENTATION	2.5	ORIENTATION	0.5	U/W GYROCOMPASS	0.2deg	
8	MANIFOLDS ANCHORS	HORIZONTAL	2.5	HORIZONTAL	1	MF LBL	0.3m	
		ATTITUDE	1	ATTITUDE	0.5	2 AXIS INCLINOMETRE	0.01deg	
		ORIENTATION	2.5	ORIENTATION	0.5	ROV GYROCOMPASS	0.2deg	
9	WELLHEAD	HORIZONTAL	2.5	HORIZONTAL	1	MF LBL	0.3m	
		ATTITUDE	1.5	ATTITUDE	0.5	2 AXIS INCLINOMETRE	0.01deg	
		ORIENTATION	5	ORIENTATION	0.5	ROV GYROCOMPASS	0.2deg	
		ELEVATION	1	ORIENTATION	0.5	BATHY SYSTEM ALTIMETER	0.1m	
10	FPSO	HORIZONTAL	5	HORIZONTAL	3	DGPS1/ DGPS2	1m/3m	
		ORIENTATION	2.5	ORIENTATION	0.5	SURVEY GYROCOMPASS	0.2deg	
11	FPSO MOORING LEGS	CORRIDOR	15	HORIZONTAL	5	DGPS+HIPAP USBL	0.5% WD	
12	FPSO SUCCION ANCHOR	HORIZONTAL	5	HORIZONTAL	2.5	LF/MF LBL	1m/0.3m	
		ATTITUDE	5	ATTITUDE	2	2 AXIS INCLINOMETRE	0.01deg	
		ORIENTATION	5	ORIENTATION	2	ROV GYROCOMPASS	0.2deg	
13	OOB/SPM	RADIUS	13	HORIZONTAL	3	DGPS1/ DGPS2	1m/3m	
14	OOB/SPM MOORING LEGS	CORRIDOR	15	HORIZONTAL	5	DGPS+HIPAP USBL	0.5% WD	
15	OOB/SPM SUCCION ANCHOR	HORIZONTAL	5	HORIZONTAL	2.5	LF/MF LBL	1m/0.3m	
		ATTITUDE	5	ATTITUDE	2	2 AXIS INCLINOMETRE	0.01deg	
		ORIENTATION	5	ORIENTATION	2	ROV GYROCOMPASS	0.2deg	
16	UMBILICAL	CORRIDOR	15	HORIZONTAL	7	DGPS+HIPAP USBL	0.5% WD	
17	UMBILICAL TDP	LONGITUDINAL	5	HORIZONTAL	1	MF LBL	0.3m	
18	SUT	LONGITUDINAL	5	LONGITUDINAL	2.5	MF LBL	0.3m	
		LATERAL	5	LATERAL	2.5	MF LBL	0.3m	
		ATTITUDE	5	ATTITUDE	2	2 AXIS INCLINOMETRE	0.01deg	
		ORIENTATION	5	ORIENTATION	2	ROV GYROCOMPASS	0.2deg	
19	OIL OFFLOADING LINES OIL OFFLOADING LINES	LONGITUDINAL	7	LONGITUDINAL	7	DGPS+HIPAP USBL	0.5% WD	
		VERTICAL	2.5	VERTICAL	1	DIGIQUARTZ	0.02% WD	
20	PRODUCTION WELL JUMPER SPOOLS	HORIZONTAL	0.05	HORIZONTAL	0.03	EHF LBL/ METROLOGY TAUT WIRE	0.03m	
		VERTICAL	0.05	VERTICAL	0.03	ROV BATHY-SYSTEM/ TP DIGIQUARTZ	0.02%WD	
		ATTITUDE	0.1	ATTITUDE	0.1	2 AXIS INCLINOMETRE	0.01deg	
		ORIENTATION	0.1	ORIENTATION	0.1	U/W GYROCOMPASS	0.2deg	
21	WI WELL JUMPER SPOOLS	HORIZONTAL	0.05	HORIZONTAL	0.03	EHF LBL/ METROLOGY TAUT WIRE	0.03m	
		VERTICAL	0.05	VERTICAL	0.03	ROV BATHY-SYSTEM/ TP DIGIQUARTZ	0.02%WD	
		ATTITUDE	0.1	ATTITUDE	0.1	2 AXIS INCLINOMETRE	0.01deg	
		ORIENTATION	0.1	ORIENTATION	0.1	U/W GYROCOMPASS	0.2deg	
22	CONTROL JUMPERS/ FLYING LEEDS	HORIZONTAL	5	HORIZONTAL	3	USBL RELATIVE	1m	
		ATTITUDE	6	ATTITUDE	2	ROV INCLINOMETRE	0.01deg	
		ORIENTATION	2	ORIENTATION	1	ROV GYROCOMPASS	0.2deg	

Note: Where not available, units are in metres or are those stated in column ACCURACY

Note: Accuracies are stated at 95% confidence level.

Horizontal 2D accuracy = 2.45 SIGMA

Vertical 1D accuracy = 1.96 SIGMA - where SIGMA is standard deviation

HIGH ACCURACY
MEDIUM ACCURACY
LOW ACCURACY

4.1.1 Survey Sensor typical accuracy

- | | |
|---|---|
| • SV sensor/profiler accuracy | 0.01 m/s @ 2Sigma |
| • CTD device accuracy | 0.005% (salinity)
0.02% (temp)
0.5% (depth range) |
| • Bathy-system Digiquartz pressure sensor | < 0.01% of water depth |
| • ROV precision echo sounder accuracy | 0.5% measured distance |
| • ROV pressure sensor accuracy | 0.01% scale range |
| • ROV gyrocompass absolute direction accuracy | 0.2° (dynamic) |
| • ROV VRU absolute accuracy | 0.1° |

4.2 Survey datum

4.2.1 Geodetic parameters

The geodetic datum system for the performance of the work shall be defined by Company in the Particular Specification.

All the co-ordinates shall be based on the single reference datum.

4.2.2 Vertical datum

All bathymetry measurements shall be referenced to Lowest Astronomical Tide (LAT) level - (unless otherwise stipulated) determined using standards recognised by the Company and relating to the working area.

5. Onboard data processing

Processing (real time and post processing) of all positioning data shall be carried out onboard.

Contractor will provide equipment and personnel to ensure that the following have been completed within 24 hours of acquisition:

- Positioning data has been checked and processed
- Statistical output proves that the data conforms to the required accuracy
- Raw data has been recorded in the relevant and agreed format. All raw data will be time tagged to GPS or UTC time, logged, and stored on a prior agreed medium
- Final processed data has been recorded in relevant and agreed format and stored on a prior agreed medium
- The Company Representative has received the data and the statistical output which should prove the conformance of the data to required specification.

Contractor's system shall be capable of storing raw data for the entire survey on a suitable and agreed medium.

If the stored raw data has been in any way filtered, smoothed or had C-O's applied within the individual sensors, then this shall be clearly indicated.