



Exploration & Production

GENERAL SPECIFICATION

SUBSEA SYSTEMS

GS SPS 001

Design philosophy and requirements for Subsea Stations

01	08/03	Change of Group name and logo
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Rev.	Date	Notes



Contents

1. Scope	4
2. Reference documents.....	4
3. Introduction	7
3.1 Definitions	7
3.2 Abbreviations	8
3.3 Responsibility.....	9
4. System description	10
4.1 System overview.....	10
4.2 Configuration of the subsea station.....	10
5. Principles for definition of service conditions	12
5.1 Design pressures for X-Mas Tree system	13
5.2 Design pressures for production guidebases and manifold systems	13
5.3 Design pressures hydraulic systems	13
5.4 Design pressure for SCSSV hydraulic supply.....	13
6. Subsea station design philosophy	13
6.1 General design philosophies	13
6.2 Well control philosophy and requirements.....	15
6.3 Hydrate prevention philosophy.....	17
6.4 Control philosophy	17
6.5 Operating and maintenance philosophy	17
6.6 Protection corrosion philosophy	17
6.7 Dependability	19
6.8 Verification and Qualification philosophy.....	19
6.9 Installation philosophy.....	19
6.10 Abandonment philosophy.....	19
7. Subsea station requirements	20
7.1 Introduction	20
7.2 General Design requirements	20
7.3 Functional and operational requirements	21



7.4	Simultaneous Operations.....	22
7.5	Hydraulic systems requirements	22
7.6	Load conditions.....	23
7.7	Material requirements	24
7.8	External corrosion protection.....	25
7.9	Mechanical protection requirements.....	25
7.10	Handling, storage transportation and installation.....	26
7.11	Identification and marking requirements.....	29
7.12	Manufacturing and fabrication requirements	30
8.	ROV/ROT Specific tools access requirements	31
9.	Mechanical completion and preservation requirements	31
9.1	Preservation.....	31
9.2	Mechanical completion.....	31
10.	Test requirements	31
10.1	Introduction	31
10.2	General requirements	32
10.3	Test facilities	33
10.4	Qualification and verification tests.....	33
10.5	Unit Factory Acceptance Test (FAT)	33
10.6	System FAT/Extended Factory Acceptance Test (EFAT).....	34
10.7	System test	36
10.8	Integration Tests (IT).....	40
10.9	Shallow water test.....	41



1. Scope

The philosophy behind this document is to provide general and fundamental specifications, which form the Basis of Design of the system.

The purpose of this specification is to describe design philosophies and overall technical requirements for the functionality of Subsea Production and Injection Stations, including structures and manifolds, tie-in systems, control systems and X-Mas tree system.

This specification covers both permanently installed equipment and associated tools and temporary equipment required for offshore installation and commissioning of the systems as well as potential intervention work. The document is valid for all phases of a field development, i.e. engineering, procurement, construction, testing, installation, commissioning, operation and abandonment.

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 general specification and all other equipment specifications referenced herein are based on:

- Project specifications
- COMPANY general specifications
- Industry standards

identified hereafter.

This specification is supplementary to the technical specifications identified hereafter, and shall therefore be used in conjunction with said documents and any other COMPANY specifications identified therein.

The Subsea Station shall comply with all relevant industry standards such as ISO, API, and other referenced standards unless otherwise stated by COMPANY.

In particular, [ISO 13628-1](#) shall be considered as a supplement to this specification.

In the event of any conflict between the reference documents, the following order of priority shall apply:

- Project specifications
- COMPANY general specifications
- Industry standards.

Within the industry standards the following order of priority shall be observed:

- ISO
- API
- EN
- Others.



Note: The EU Pressure Equipment Directive (97/23/EC) becomes mandatory from 29 May 2002. This directive may require certain additional and new measures to be taken by the SUPPLIER of pressurised equipment. CONTRACTOR shall identify any implications of the above.

Standards

Reference	Title
ISO 13628	Petroleum and Natural Gas Industries - Design and operation of subsea production systems
ISO 13628 Part 1	General requirements and recommendations
ISO 13628 Part 4	Subsea Wellhead and Tree Equipment
ISO 13628 Part 6	Subsea Production Control Systems (FDIS rev.)
ISO 13628 Part 8	ROV with Subsea Production System
ISO 13628 Part 9	Remotely Operated Tools
ISO 90006-4	Quality Assurance standards - Guide to dependability programme management.
EN 287	Approval testing of welders - Fusion welding
EN 288	Specification and approval of welding procedures for metallic materials
EN 10204-31B	Metallic products types of inspection documents
EN 10204-31C	
NACE MR 01-75	Material Requirements. Sulphide Stress Cracking Resistant, Metallic Material for Oil Field Equipment

Professional Documents

Reference	Title
DNV Certification note 2.7-1	Offshore Freight Containers
DNV	Rules for planning and execution of Marine Operations (RMO)
DNV 81	Rules for design of submarine pipelines
DNV 96	Rules for design of submarine pipelines
API 6A	Specification for Wellhead and Christmas Tree Equipment
API 8C	Drilling and Production Hoisting Equipment
API 16A	Specification for Drill Through Equipment
API 16D	Control Systems for Drilling Well Control
API 17G	Design and Operation of Completion/Workover Riser Systems



Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
ASME/ANSI B 31.3	Chemical Plant and Petroleum Refinery Piping
NAS 1638	Cleanliness requirements of parts used in hydraulic systems
ASME IX	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS COR 100	Design of cathodic protection of offshore structures
GS COR 350	External protection of offshore and related structures and equipment by painting
GS PLR 100	Submarine Pipeline Systems
GS PLR 231	Fabrication of hot bends for pipelines and flowlines
GS PLR 232	Carbon steel flanges for pipelines
GS PVV 614	Welding of duplex and superduplex stainless steel pipework
GS SPS 002	Design of Subsea Structures
GS SPS 003	Foundation design considerations for Subsea Structures
GS SPS 004	Subsea Manifold System Gate Valves
GS SPS 005	Subsea Ball Valves
GS SPS 006	Service Valves in Subsea Stations
GS SPS 007	Tie-In Systems
GS SPS 008	Thermal Insulation of Subsea Stations
GS SPS 009	Corrosion Protection of Subsea equipment
GS SPS 010	Preservation Requirements for Subsea Packages
GS SPS 011	Mechanical Completion Requirements for Subsea Equipment
GS SPS 012	Documentation Requirements for Subsea Stations

Reference	Title
GS SPS 013	Wellhead and Guidance Systems
GS SPS 014	Drill through Horizontal X-Mas tree Systems
GS SPS 015	Gate Valves and Actuators in Subsea X-Mas tree Systems
GS SPS 016	Subsea Insert Chokes and Associated Running and Retrieval Tools
GS SPS 017	Workover/Completion Systems
GS SPS 018	Light intervention system for DTHT
GS SPS 019	Subsea Production Control Systems
GS SPS 020	Subsea Control Unit Functional Requirements
GS SPS 021	Subsea Mateable Electrical/Optical Connectors
GS SPS 022	Environmental testing of Subsea Electronics
GS SPS 023	Cleaning and Flushing of Hydraulic Systems
GS SPS 024	Subsea mechanical quarter turn actuator (manually operated gearbox)
GS SPS 025	Subsea hydraulic spring return quarter turn actuators
GS STR 001	Weight monitoring and weighing of offshore units
GS STR 101	Design of offshore jacket and subsea structures
GS STR 201	Materials for offshore steel structures
GS STR 301	Fabrication of offshore steel structures
GS STR 401	Load-out, sea-fastening, transportation and installation of offshore structures
GS STR 404	Marine aspects for load-out, transportation and installation of offshore structures

3. Introduction

3.1 Definitions

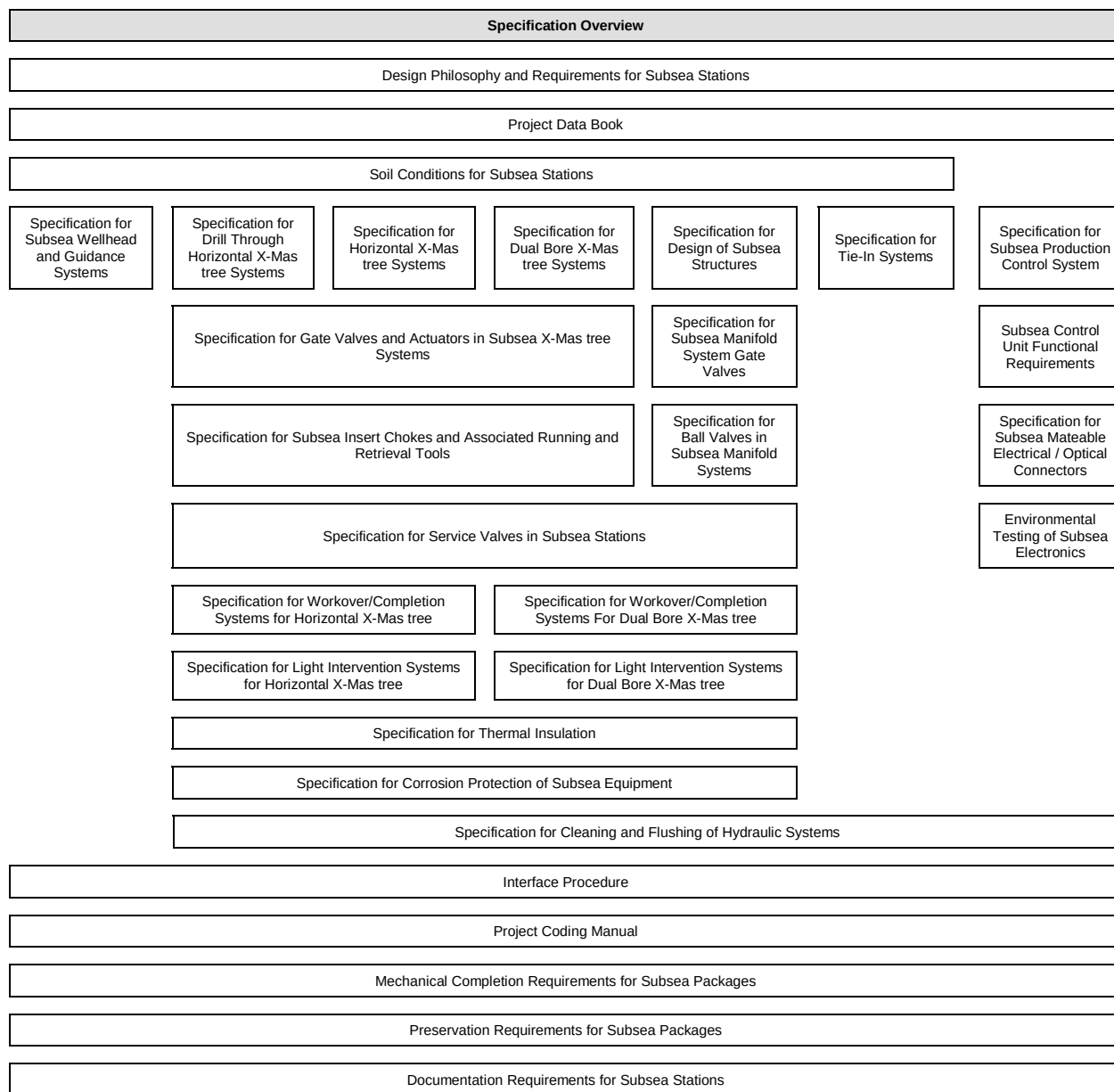
Unit	Individual equipment item such as a X-Mas tree assembly, a subsea control module, etc.
System	Combination of Units serving certain functions in the subsea system, such as X-Mas tree System, Production Control System, etc.
Subsea Station	Combination of Systems forming a complete Subsea Production or Injection Station.
Internal Interface	Interface between Units and Systems supplied by the same CONTRACTOR.
External Interface	Interface between Units or Systems supplied by one CONTRACTOR and equipment and services supplied by other CONTRACTOR(s).



Lifting gear

Any equipment with the primary function of connecting a Unit to a crane hook, including pad eyes permanently fixed to the load bearing structure of the Unit to be lifted. A transportation/test skid used for lifting shall be treated as lifting gear.

Figure 1 - Specification Overview



3.2 Abbreviations

The following abbreviations are used in this specification:

- API American Petroleum Institute
- BOP Blow-Out Preventer



- CCDS Cement and Cuttings Disposal System
- CP Cathodic Protection
- DTHT Drill Trough Horizontal Tree
- E&P Exploration and Production
- EFAT Extended FAT
- EN European Norm
- EQD Emergency Quick Disconnect
- FAT Factory Acceptance Test
- FPU Floating Production Unit
- FPSO Floating Production Storage and Offloading unit
- HXT Horizontal X-Mas tree
- ISO International Standardisation Organisation
- LICS Light Intervention Control System
- MC Mechanical Completion
- MCM Manifold Control Module
- MDS Material Data Sheet
- MT Metric Tonnes
- PCS Production Control System
- PGB Permanent Guide Base
- PLM Pigging Loop Module
- ROV Remote Operated Vehicle
- SAM Subsea Accumulator Module
- SCM Subsea Control Module
- SDU Subsea Distribution Unit
- SIWHP Shut-In Wellhead Pressure
- SCSSV Sub Surface Safety Valve
- STT Surface Test Tree
- SSTT Subsea Test Tree
- WH Wellhead
- WOCS Workover Control System

3.3 Responsibility

It is the responsibility of anyone who supplies equipment to this specification to ensure compliance with the requirements defined by this specification, other referenced standards and statutory requirements.

Deviation from any of the requirements defined herein shall be declared and treated as a non-conformance.

4. System description

4.1 System overview

A complete subsea production or injection system consists of one or more subsea stations with flowlines and umbilicals connecting the stations to a process facility. The Subsea Station is defined to include the following systems:

- Wellhead System
- X-Mas tree System
- Subsea Production Control System including topside equipment
- Tie-in System
- Structures (including manifolds).

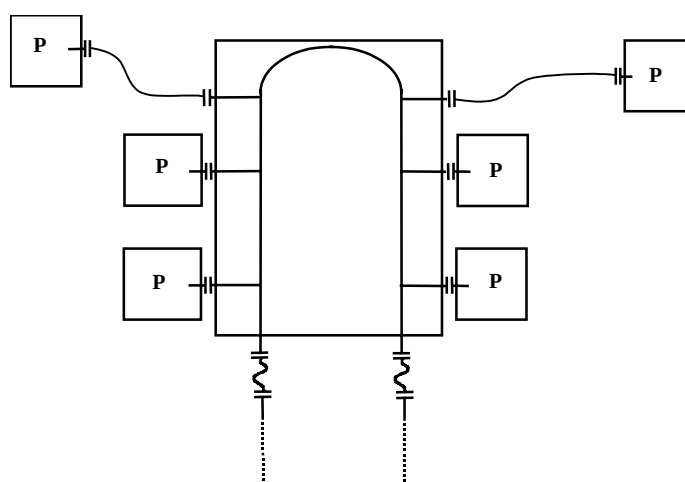
This document is valid for the Subsea Station, which is defined to include all Systems identified above.

Flowlines and Umbilicals are not part of the Subsea Station.

4.2 Configuration of the subsea station

The systems covered by this specification shall be designed for use in any of the following development concepts:

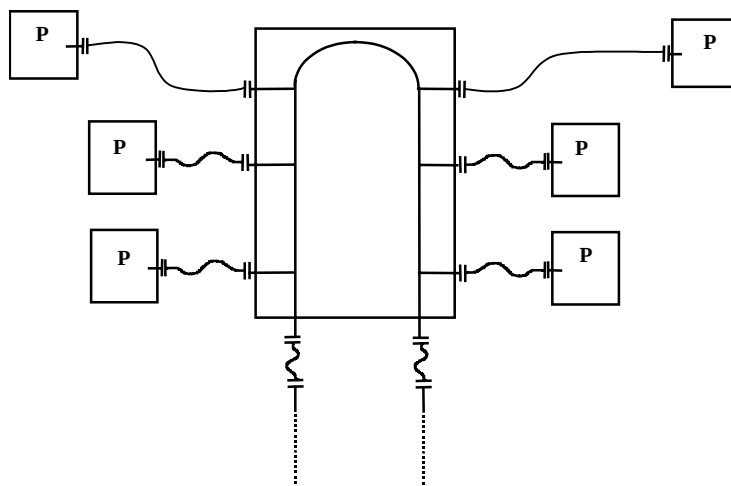
- **Concept 1:** Multiwell Template with Production Manifold:
 - Concept 1A Integrated template/manifold
 - Concept 1B Modular template/manifold



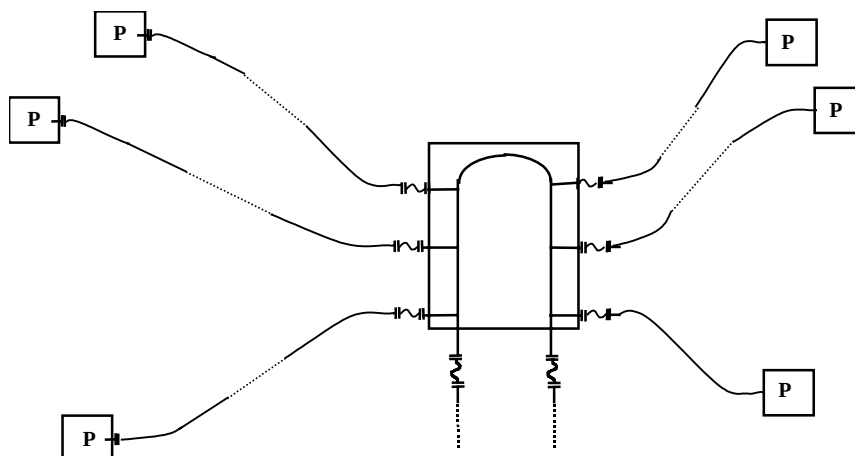
Typical 4-slot Template with two spare off template slots

- **Concept 2:** Individual Wells Connected to a Subsea Manifold Centre

- Concept 2A: cluster configuration

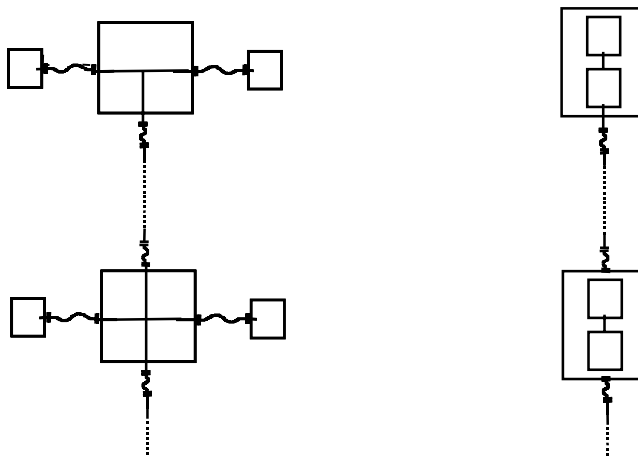


- Concept 2B: Satellite configuration



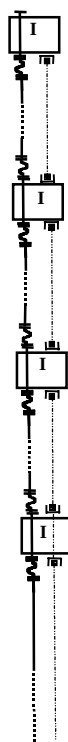
Typical 4-Slot manifold configuration with provision for two spare slots

- **Concept 3: 2-slot Structures (water or gas injection)**



Two different versions of 2-slot structures

- **Concept 4: Piggy-back Individual Wells (water or gas injection)**



5. Principles for definition of service conditions

Service conditions shall be established in accordance with [ISO 13628-4](#) section 4.

All components, Units and Systems used as primary barriers to contain or control well pressure shall be designed in accordance with the principles defined in section 5.1. The battery limit shall be outside the wing valve or choke valve on a subsea tree. Pipe spools, flowline/service line

connectors, pig launchers, etc. outside the battery limit shall be treated as manifold equipment in accordance with section 5.2.

5.1 Design pressures for X-Mas Tree system

The Subsea X-Mas tree system design pressure is provided in the following document [GS SPS 014](#).

5.2 Design pressures for production guidebases and manifold systems

Design pressures for production guide bases, jumper modules and manifold systems shall be established on the basis of the following principles:

- The production piping system shall be designed in accordance with [DNV 81](#). [DNV 96](#) rules could be applied in some cases, with COMPANY agreement
- Service lines, hydraulic lines, scale inhibitor, chemical injection and gas lift lines shall be designed in accordance with [DNV 81](#)
- On injection systems (gas or water) maximum operating pressure shall be established on the basis of the surface facility relief valve operating pressure.

Reference is made to [GS SPS 002](#) for further information on design requirements for manifolds.

5.3 Design pressures hydraulic systems

Hydraulic systems shall be designed using the following guidelines:

- Working Pressure = Regulated Pressure from the HPU
- Working Pressure $\leq$ Maximum Working Pressure
- Design Pressure = 1.1 * Maximum Working Pressure
- Relief Valve Setting $\leq$ Design Pressure

The Design Pressures and Maximum Working Pressures for the different parts of the system shall be clearly stated in CONTRACTOR's documentation.

5.4 Design pressure for SCSSV hydraulic supply

Pressure rating for Surface Controlled Subsurface Safety Valves (SCSSVs) and associated hydraulic circuits will be agreed with COMPANY when location and type of SCSSV are established.

6. Subsea station design philosophy

6.1 General design philosophies

All systems within the Subsea Station located on the seabed shall be designed in accordance with the following overall design philosophy:

- All subsea systems shall be designed for diverless and guidelineless installation and intervention.
- Field proven equipment and techniques shall be preferred unless newly developed techniques providing improved performance without compromising safety can be documented.

- The subsea system shall be modularised in such a way that functional components requiring maintenance or replacement can be disconnected, retrieved to surface, replaced and tested either as part of a module or as individual components. All modules shall preferably be independently retrievable.
- All components vital to safe and efficient performance of the systems, or requiring surface maintenance during the field life shall be subsea retrievable. Typical such items are: Choke valve, Control Module, Multiphase Meter, Sand Detector, etc.
- Design of Subsea Stations shall minimise the risk of snagging ROV umbilicals.
- Simple solutions shall be adopted for optimum reliability.
- The Systems shall be designed to allow total interchangeability of Units designed to fulfil the same function, such as SCM's, Choke Valves, etc.
- The equipment shall be designed for access by both working and inspection ROVs when required for inspection and/or intervention.
- Lightweight Units and tools shall preferably be designed for deployment by wire cable methods.
- The system shall be designed for easy fault diagnosis without system retrieval.
- All tools for valve operation shall be ROV deployable unless otherwise justified by the size of the valve.
- Design of equipment and interfaces shall be standardised wherever possible.
- No Cement and Cutting Disposal System is required unless specifically asked for by Project, therefore Template-based design shall cope with accumulation of cement and cuttings without necessitating remedial intervention.

6.1.1 Concept 1A: Integrated template/Manifold design philosophy

For an integrated template concept, a full finite element model shall be developed including:

- Soil model based on Project specific soil data
- The appropriate Foundation system
- Drilling structure and equipment supporting/protection structure
- Drilling/Intervention/Flowline installation and operational loads.

Foundation behaviour and performance shall be studied and checked for:

- Various drilling sequences, i.e. from first well being drilled to last well
- Well completion/intervention operations
- Flowlines and Umbilicals connection operations
- Flowlines thermal expansion aspects.

An ROV access study shall be carried out using a 3-D model comprising Structures, ROV and Units/Components to be accessed. ROV intervention shall be checked for each and every Unit or Component potentially requiring ROV access.

All main Units such as X-Mas tree, Manifold shall be independently retrievable i.e. without necessitating prior removal of another Unit.

6.1.2 Concept 1B: Modular template philosophy

Design philosophy principles listed in section 6.1.1 apply for modular template design.

The design of a modular template system shall allow for RIG deployment and installation.

System design shall allow for drilling and completion operations of some wells after manifold installation.

System shall allow for on-template slots to be converted into tie-in slots for off-template wells through adequate adapters called "Jumper Modules".

6.1.3 Concept 2A: Individual wells connected to a subsea manifold centre in cluster configuration

In this configuration the tie in distance of the cluster wells is approximately 20 to 30 metres.

For a cluster configuration a finite element model shall be developed including:

- Soil model based on Project soil data
- Foundation system
- Equipment supporting/protection structure
- Intervention/Flowline installation and operational loads.

An ROV access study shall be carried out with a 3-D model comprising structure, ROV and unit/component to be accessed. ROV intervention shall be checked for each and every unit or component potentially requiring ROV access.

6.1.4 Concept 2B: Individual wells connected to a subsea manifold centre in satellite configuration

In this configuration the tie in distance of the cluster wells can be several hundred metres.

The principles listed above in 6.1.3 apply for a satellite configuration.

6.1.5 Concept 3: 2-slot structure for water or gas injection

The principles listed for modular template (section 6.1.2) apply in whole for 2-slot injection structure.

6.1.6 Concept 4: Individual water or gas injection in a piggy back mode

Individual X-Mas trees are connected to a single water or gas line, either through a flow base or through a T-structure. Reference is made to the Scope of Work for the connection principles.

6.2 Well control philosophy and requirements

6.2.1 Barrier requirements

6.2.1.1 General

This chapter describes the general philosophies and requirements for well control, including the overall principles for well and manifold barriers, kill methods and simultaneous operations. Project specific needs may require application of other well control elements in addition to, or in place of, those described below.

6.2.1.2 Barrier requirements

Each barrier element shall be designed such that:

- It can be pressure tested
- The position/location and status can be known at all times
- Re-establishment of a barrier can be achieved quickly
- It is independent of other barrier elements in conjunction with the same source of influx
- It can operate competently in the actual environment (pressure, temperature, fluids).

It shall be possible to verify the integrity of a barrier by pressure testing to design pressure, in the direction of the potential flow (i.e. from upstream side of the barrier).

6.2.2 Well barriers

All well activities shall be performed with two (2) barriers to prevent uncontrolled blow-out from the well. Accepted barriers in this context are:

- BOP/LRP/SSTT
- X-Mas tree
- Mechanical Plug
- High pressure riser (Workover riser) with lubricator and pack box
- Wellhead/tubing hanger w/seals and plug(s)
- Surface Test Tree.

If a well barrier is lost, all activities in the well shall be directed towards re-establishing the lost barrier or establishing alternative barriers.

BOP or other equipment/systems serving the function of the BOP, such as Lower Riser Package and Subsea Test Tree, shall be capable of shearing the work string wireline/coiled tubing, and sealing off the well bore afterwards. There are no requirements for ability to shear tools or other units with increased wall thickness that temporarily pass through the BOP.

6.2.3 Barriers downstream X-Mas trees

Accepted barrier elements downstream the wing valve or choke valve on X-Mas trees, such as on production guide bases and manifold systems are:

Barrier location	Acceptable barrier element
Environmental barrier on lines exposed to well bore fluids/pressure during normal production	One pressure resistant cap with metallic seals
Environmental barrier on lines exposed to well bore fluids/pressure during temporary operations	One tested isolation valve
Environmental barrier on other lines during normal productions and temporary operations (such as hydraulic lines inhibitor lines, etc.)	One isolation valve

6.2.4 Well kill requirements

The primary well kill method will be by pumping directly into the well bore. The main principle is pumping through the marine riser choke and kill line below closed BOP rams, or through the Workover Riser and Subsea Test Tree or Lower Riser Package.

The pressure rating of all equipment affected by well kill pressure, shall be determined by taking into account actual friction losses in the line between the surface facility and the reservoir.

6.2.5 Simultaneous operations

Simultaneous operations are covered in Project Philosophy documentation:

- Operating Philosophy
- Intervention Philosophy
- Drilling Philosophy.

6.3 Hydrate prevention philosophy

The complete Subsea Station shall be designed with the objective of avoiding hydrate formation. A strategy for displacement of the contents of all flow paths shall be developed. The design shall facilitate remote filling of all parts of the production flow path with inhibitor fluid before start-up of individual wells and before start-up of the complete Subsea Station. Dead ends shall either have injection points or geometry such that water is drained.

The production flow path shall be designed with the objective of avoiding low points, which may generate water accumulation. If low points cannot be avoided, such areas shall be designed to be always filled with inhibitor and with a minimised risk for gradual accumulation of water during production. Possible cold spots shall be identified and provided with an adequate thermal insulation system if required.

6.4 Control philosophy

Subsea production control system philosophy is described in the following document [GS SPS 019](#).

6.5 Operating and maintenance philosophy

Operating and maintenance philosophy is described in document: "Field operation philosophy"

6.6 Protection corrosion philosophy

6.6.1 Internal corrosion prevention

Prediction of corrosion risk is based on the following principal corrosion phenomena:

- CO₂ corrosion
- Erosion corrosion
- Souring risk prediction and evaluation of the souring impact regarding H₂S cracking risks
- Microbiological Influenced Corrosion (MIC).

6.6.1.1 Oil production equipment

The philosophy is based on the use of corrosion resistant material for equipment in contact with the produced fluids, from wellhead to flowlines.

Accepted material for these lines are:

- Carbon steel with 316L stainless steel internal cladding
- Massive duplex 22.05 in annealed condition
- Or other options to be approved by COMPANY.

6.6.1.2 Gas injection equipment

The philosophy is to use H₂S resistant carbon steel.

Corrosion allowance shall be 1.5 mm thickness.

6.6.1.3 Water injection equipment

The philosophy is to use carbon steel since the injected water is submitted to anti-corrosion treatment.

Internal coating of water injection line and equipment is not required.

Corrosion allowance shall be 1.5 mm thickness.

6.6.1.4 Service lines/Chemical lines/Hydraulic lines

Those lines shall be fully corrosion resistant.

Material required for these lines are:

- Annealed AISI 316L
- Duplex 22.05 in an annealed condition
- Or other options to be approved by COMPANY.

6.6.2 External corrosion prevention methods

The system design shall include a corrosion protection system based on a combination of cathodic protection and surface coating. Surfaces shall be painted to limit anode consumption.

The corrosion protection system shall be designed for the lifetime of the installation.

Emphasis is also placed on the impact of low negative potentials on Hydrogen Induced Cracking risk of high strength materials.

Each retrievable module, including jumpers shall have its specific protection system based on a combination of cathodic protection and surface coating.

Foundation structures (wellhead, manifold e.g.) shall be protected against corrosion by a combination of surface coating and cathodic protection. Sacrificial anodes are acceptable for the submerged and buried equipment.

6.6.3 Sand monitoring in production equipment

CONTRACTOR shall identify and recommend the best-suited sand control monitoring system for the application. Sand monitoring principles and location of monitoring devices shall be discussed and agreed by COMPANY.

6.7 Dependability

Dependability encompasses Reliability, Availability and Maintainability.

CONTRACTOR shall develop and implement a dependability programme. This document shall describe and formalise the dependability policy in accordance with Operator's requirements, organisation, resources and dependability assurance. This programme shall be applied from conceptual phase to delivery of equipment.

Reference is made to [ISO 90006-4](#) "Quality Assurance standards-Guide to dependability programme management".

A RAM analysis tool should be intensively used during all system design phases.

Dependability targets shall be checked against design at each stage of project and be used as a decision aid tool as well as for developing a qualification/verification program.

Input data to the RAM analysis shall be fully documented either by experience feed back or specific studies or testing.

6.8 Verification and Qualification philosophy

CONTRACTOR shall develop and implement a verification-qualification programme. This document shall identify down to the component level the design review, manufacture control, qualification and testing activities required and carried out in order to reach the dependability objectives.

Equipment lacking the necessary track record and hence requiring full qualification for the application shall be clearly identified at an early stage during the bid process. CONTRACTOR shall develop a realistic qualification program and schedule for submission to COMPANY before contract award.

Field proven equipment but requiring minor modification or upgrading shall be subject to a specific qualification programme unless otherwise agreed by COMPANY.

Equipment used for qualification purposes shall not be reused for the Project unless agreed by COMPANY.

6.9 Installation philosophy

At all stages of running and installation of subsea equipment, the sequence of operations must be reversible with the exception of some specific foundation systems (e.g. driven piles type foundation, etc.).

Integrated template system shall be designed for installation by specific handling support vessels.

Modular systems shall be designed for installation by both drilling RIG and handling support vessels.

As a general practise, the handling surface unit shall be moved off the vertical of the final location prior to handling of heavy equipment. The surface unit shall stay around this position until a safe distance above seabed is reached before moving over to the final location.

6.10 Abandonment philosophy

Reference is made to [ISO 13628-1](#) section 8.7 "Decommissioning".

In addition CONTRACTOR shall develop a decommissioning plan with corresponding operational procedures for the Subsea Production System.

7. Subsea station requirements

7.1 Introduction

This chapter provides a set of general requirements applicable to the entire Subsea Station, Systems and/or Units, whichever is relevant.

7.2 General Design requirements

All systems within the Subsea Station located on the seabed shall be designed in accordance with the following overall design requirements:

- All Units shall be designed and qualified for potential service conditions expected during their design life, including drilling, completion, installation and workover operations.
- Assemblies and components such as valves and seal assemblies which will be exposed to chemicals or particles carried by the well fluids causing chemical deterioration, collection of debris or abrasive action, shall either have proven compatibility with the specified conditions, or be qualified through tests simulating representative field conditions.
- The equipment shall be designed with due consideration to ease and speed of installation, operation and maintenance and where possible use of standard tools.
- The number of seals made up under water shall be minimised. All seals made up under water shall be new, i.e. not previously energised. Seal areas on equipment installed under water and temporally not in use, shall be protected against mechanical damage and corrosion. It shall be possible to clean all seal areas using either standard industry tools/equipment or dedicated tools supplied as part of the subsea station.
- All connectors shall have test ports for verification of seal integrity to full working pressure. In case of test of a seal from the backside, reduced pressure can be accepted. Connectors and flanged connections incorporating a dual seal arrangement shall include facilities for testing between the seals.
- Weight of Units including shipping skids and lifting devices shall be optimised in order to ease offshore handling operations.
- All equipment shall be vibration resistant to tolerate road and sea transportation, rig handling, drilling and operation.
- Any equipment, which requires personnel to climb onto individual Units or Units stacked up on each other, shall be furnished with temporary foot steps and hand holds, ladders, protection and floor grating as required by common practise.
- All mechanical components which are subject to relative motion between metal faces during make-up of e.g. a preloaded seal or a connection (high contact stress), shall be designed with adequate differential hardness to establish correct contact load. This is to avoid any form of galling or other mechanical damage due to friction between the components.

- Components of a Unit, which are electrically isolated from the Cathodic Protection (CP) system of the Unit, shall either be electrically connected to the Unit by cables, or shall be made of a material, which does not require cathodic protection.
- The design phase shall include the main procedures for maintenance, operations, installation, retrieval and abandonment.
- All equipment shall be designed with the objective of achieving safe handling and operation through all stages of assembly and testing, transportation, installation, commissioning, operation and removal. All handling and operational procedures shall be reviewed, with particular attention to methods and support facilities.
- Heavy modules designed for moon pool deployment from semi submersible or mono hull vessels shall be designed for safe skidding on deck and guidance through the moon pool. The design shall facilitate easy interfacing to existing skidding and moon-pool guiding systems.
- All permanently installed Units shall be prepared for complete removal following abandonment of a well or of the Subsea Station.
- Production or injection jumpers connecting a X-Mas tree to a manifold or a flowline shall normally not exceed 30 m in length, unless otherwise stated or agreed with COMPANY.

7.3 Functional and operational requirements

This section describes the overall functional and operational requirements for the Subsea Systems and their individual Units:

- Modules, packages, individual components and interfaces shall be designed to accommodate a vertical landing velocity of 0.8 m/s if run on drill pipe, and 1.5 m/s if run on wire.
- Passive or active soft landing systems shall be considered for modules with interfaces requiring accurate control during landing subsea.
- Running tools shall complete their intended operation in a single trip.
- Hydraulically operated valves shall include a mechanical override, linear or rotary, with adequate facilities for operation by ROV. Direction of rotation shall be clockwise to close and counter-clockwise to open. The mechanical override system shall be designed with capacity to operate the valve with maximum rated differential pressure across the valve. It shall tolerate all relevant loads from the ROV and tool system, including max. output torque from the actual ROV tool.
- Hydraulic functions which are critical with respect to safe retrieval of modules to surface in the event of hydraulic blocking, shall be designed for draining of the hydraulic circuit by cutting lines with standard ROV carried cutting tool. The hydraulic loop shall be properly marked with function using Aquasign or similar legible marking.
- Visual position indicators shall be included on all valve and actuator functions displaying function status (end positions and full travel) for observation with ROV. For all functions incorporating ROV override, the position indicator shall be visible from the operating ROV with the tool and ROV in operating position.
- The design of ROV valves panel shall allow for an impact load equal to a mass of 1000 kg at 0.5 m/s velocity. The ROV valve panel shall be equipped with suitable ROV grabber bars for safe valve operation in accordance with [ISO 13628](#).

- Bores and flanges for mounting of pressure and temperature sensors shall be carefully located and designed, to provide the best possible conditions for sensor reliability and measurement accuracy. The risk of clogging of sensor bores (hydrates, wax, scale, sand, etc.) shall be considered when defining sensor location. The sensor housings shall have the possibility to be thermally insulated to reduce heat transfer, if required. Sensor cables shall be routed, supported and protected as required to minimise the risk of damage.
- Flow paths, valve configuration and monitoring functions on all Units and Systems shall be designed with the objective of providing fast and efficient barrier testing.
- COMPANY policy for operations above subsea installations is to move the vessel off location, during lifting of heavy equipment. The subsea equipment and structures shall be designed to minimise the risk and consequences of sweeping and snagging of wires and umbilicals.
- All connectors shall include a proven mechanical locking arrangement to avoid accidental unlocking of the connectors resulting from impact loads, vibration, thermal loads or any other loads affecting the locking mechanisms.
- All connectors shall incorporate a mechanical means of releasing the connector in the event of failure on the primary hydraulic unlock function. A secondary hydraulic unlock function, independent from the primary unlock function, is also acceptable.
- Hydraulic couplers used for chemical injection lines shall have metal seals.

7.4 Simultaneous Operations

The system design shall allow for simultaneous drilling/workover and production operations.

Simultaneous operations shall be closely investigated from a safety viewpoint by COMPANY.

Live wells should be isolated from the reservoir by a minimum of two pressure containing barriers.

7.5 Hydraulic systems requirements

This section describes the overall requirements for selection of hydraulic fluids and design of hydraulic systems for the subsea Systems and their individual Units.

- Open loop systems shall be utilised. Release of hydraulic fluid to the sea is acceptable within the acceptable toxicity levels set in recognised maritime standards.
- All components shall be qualified for use with both mineral oil and water based control fluids, satisfying the requirements to temperature stability and water compatibility. The components shall be qualified for each particular type of control fluid the components will be exposed to.
- For production control systems, water based fluids shall be used. Long tie back distances or other reasons may dictate the need for particularly low viscosity fluids to achieve acceptable response times.
- The WOCS and LICS shall utilise the same hydraulic fluid as the PCS.
- Design pressure shall be as described in section 5.3. However, for cases where there is a need to limit or reduce actuator sizes, higher design pressures shall be considered.
- Specific filling, cleaning and flushing procedures shall be provided for all hydraulic components and systems. Hydraulic lines and actuators shall be designed for through

flushing with ports for discharge of both fluids and air (or other gases) and for easy fluid sampling.

- Components and piping exposed to hydraulic fluid shall be assembled and delivered according to **NAS 1638** class 6. Hydraulic power units shall supply fluid according to class 6. During operation the systems shall be capable of maintaining a class 8 level of cleanliness, however, all systems shall be designed to tolerate class 12 operational conditions for a period of minimum years.
- All equipment shall be compatible with the selected hydraulic fluid and other relevant chemicals.
- Hydraulic connectors shall be designed with hydraulic areas such that the open function provides a 25% greater force than the lock function for the same hydraulic pressure. Hydraulic cylinders shall be utilised such that they are retracted with the connector locked.
- All hydraulic piping associated with permanently pressurised lines, LP/HP and chemical injection lines, shall be continuous, i.e. without welds, to minimise possible leak paths. Hydraulic fittings i.e. end terminations, shall be of NPT or Autoclave type, dependent on the pressure requirement. All fittings used shall be fitted with anti rotation nuts.
- Design of hydraulic couplers shall allow subsea making and unmaking under pressure. The design shall minimise seawater ingress in the hydraulic systems during connection operations.

7.6 Load conditions

Equipment shall be designed to withstand the most unfavourable of the following load conditions:

- Operational and environmental loads acting simultaneously
- Accidental loads
- Test loads
- Transportation loads
- Installation loads
- Fatigue loads.

For each of the above load conditions, and for each component or cross-section to be considered, the most unfavourable combination, position and force direction which may act simultaneously shall be used in the design analysis.

Design loads and conditions not provided by COMPANY shall be assessed and specified by CONTRACTOR and presented in the relevant design documentation for COMPANY review and acceptance.

A design analysis shall be based on accepted principles of static, dynamic and strength of materials. A combination of tests and theoretical calculations may also be used. The design analysis shall determine all relevant load capacities for structural components and interfaces.

Calculation methods and design/safety factors shall be selected in accordance with **GS STR 101**, **ISO 13628-1** and other standards referenced therein.

7.7 Material requirements

7.7.1 Material selection

Material selection shall be done in accordance with corrosion protection philosophy described in section 6.6.

Carbon steel components shall have UNS N06625 cladding in all areas exposed to well fluids.

Hydraulic fittings shall be made from AISI 316 or upper grade.

Material selection of components located inside housings/containers/chambers (such as actuator components) has to accommodate potential water ingress due to seal failure or other causes.

The risk of hydrogen induced cracking due to cathodic protection shall be evaluated as part of the material selection.

The material selection shall be documented in a Material Selection Report.

7.7.2 Valve and Choke Valve Components

Valve and Choke Valve components such as gates, balls, seats, stems, etc., which are exposed to high contact loads in dynamic situations, shall be made of materials with appropriate mechanical strength, surface finish and hardness to avoid loss of functionality and/or sealing capability. If hard facing material is applied (such as e.g. Tungsten Carbide), fully qualified application processes such as High Velocity Oxygen Fuel (HVOF) or D-gun process shall be used.

7.7.3 Metallic seals and seal surfaces

All carbon steel seal surfaces permanently installed subsea, including areas not permanently used, shall be overlaid with corrosion resistant alloy, typically UNS N06625.

Seal materials shall be galvanically compatible with the seal areas and satisfy all requirements of [API 6A](#).

The seal area shall be of a harder material than the seal element, with a difference in hardness of minimum 50 Brinell units.

7.7.4 Non metallic seal materials

Non metallic seal materials shall be selected on the basis of service condition and lifetime required. The seal materials shall be compatible with all chemicals and fluids the seals may be exposed to, as well as interfacing metallic components.

7.7.5 Material certificates

All carbon steel materials shall be certified in accordance with [EN 10204-31B](#).

All stainless steel materials shall be certified in accordance with [EN 10204-31C](#).

The mechanical testing shall be carried out in a laboratory, which meets the requirements of EN standards.

7.8 External corrosion protection

7.8.1 General

The system design shall include a corrosion protection system based on a combination of cathodic protection and surface coating, in accordance with the principles for corrosion protection defined in **GS COR 350** and **GS COR 100**.

Metallic materials in contact with seawater shall, in general, be cathodically protected. Surfaces shall be painted to reduce anode consumption. The following requirements shall apply:

- The corrosion protection system shall be designed for the lifetime of the installation.
- The design shall provide reliable electrical continuity for each individual element within the subsea production system. Components where electrical continuity to the cathodic protection system cannot be ensured shall be fabricated in materials resistant to seawater corrosion. The surface area shall be accounted for in the design of the cathodic protection.
- Coated bolts and nuts shall include a means of ensuring electrical continuity with the cathodic system (such as serrated washers or other).

7.8.2 Surface protection

Surface preparation and protective coating shall be in accordance with **GS COR 350**.

Coating system selection and surface preparation shall be in accordance with **GS COR 350**.

7.8.3 Cathodic protection

Cathodic protection design and manufacturing of sacrificial anodes shall be in accordance with **GS COR 100**.

The cathodic protection system shall be sized for the design life of the structure.

For calculation of surface areas the latest revision of drawings shall be used.

The design shall provide reliable electrical continuity to each individual element within the Subsea System. Electrical continuity checks shall be performed to verify adequate protection.

7.8.4 Monitoring

The structure and equipment of the manifold and wellheads will be monitored by cathodic protection measurements on the structural parts. A specific unpainted steel plate shall be welded to the structure for easy measurement by ROV. In addition, a stand-off anode is to be installed on each subsea unit for measurement of current drain during subsea inspection.

A requirement/benefit study of an automatic cathodic protection monitoring device shall be carried out by CONTRACTOR. The requirement for Zn reference electrode on each manifold and wellhead needs to be assessed by CONTRACTOR.

7.9 Mechanical protection requirements

All permanently installed equipment shall be protected against dropped objects.

- The permanently installed X-Mas tree and manifold equipment shall incorporate means of protection capable of withstanding impact energy of 10 kJ from a dropped object of 100 mm diameter. The design shall ensure that the impact energy is either fully absorbed

by the protection design or transferred to the soil through the X-Mas tree and wellhead, without damage to the Unit affecting its functionality or pressure integrity.

- A pressure barrier component, or part of such, shall tolerate impact from a 10 kJ dropped object without loss of its sealing capability and barrier function.
- Elements closely interfacing to, or connected with, a pressure barrier element such as a valve actuator, shall be designed such that it will not obstruct the barrier element in such a way that loss of the barrier can be a consequence if the element is hit by 10 kJ. The stem seal system shall be designed to maintain its sealing capability with the actuator hit by a 10 kJ dropped object.
- Fragile equipment such as piping, valves, actuators, cables, sensors, etc. shall be protected against ROV collision or ROV umbilical snagging.
- All hydraulic pipe work shall be protected against impact loads from dropped objects and other damage during normal handling or use, both offshore and onshore. Attachment of the pipe work shall be by use of dedicated brackets, designed to avoid vibration. Use of load bearing bolts or pressure containing connections such as actuator flanges, etc. for attachment of brackets, is not permitted.
- Adequate protection means shall be provided for during storage, testing, transportation and installation for all hydraulic/electric stab coupler parts, male or female, to prevent particle contamination or damage during normal activities. Any subsea protector shall be ROV installable and removable.
- All re-entry hubs shall be provided with lightweight ROV operable protection covers to prevent collection of debris or damage to seal surfaces and couplers during intervention operations or periods of temporary abandonment.
- Critical components exposed to dropped objects and/or ROV impact during intervention, such as sensors, and non-ROV replaceable cables, small bore valves, etc., shall have specific local protection.

7.10 Handling, storage transportation and installation

7.10.1 General requirements

This section defines general requirements for handling, load-out, storage, transportation and installation of Subsea Systems and Units. For detailed design requirements of the individual Units, reference is made to the equipment specifications. The following general requirements apply:

- All Units shall be provided with the necessary bumper bars and/or transportation skids/boxes/frames and protective covers required for safe handling and transportation onshore and offshore.
- All Units shall be provided with lifting points and attachment points with the necessary equipment to lift and secure Units during land and sea transportation, transfer between offshore vessels (monohull or RIG in case of modular system) and onboard handling and storage.
- Lifting devices for all Units shall be provided. This shall include but not be limited to lifting subs, spreader bar arrangement, etc., all suitable for lifting in onshore and offshore conditions, both in air and submerged as required.

- Lifting points, load bearing structures and associated lifting devices shall be designed and certified in accordance with **GS STR 401**.
- All Units subjected to sea transportation shall have designated facilities (pad eyes or similar) for sea fastening, clearly marked with "Sea Fastening Only". All other equipment or modules which are not suitable for transportation in baskets or containers, shall be furnished with facilities for sea fastening as appropriate, and meet **GS STR 401** requirements.
- Test and transportation skids may be combined Units.
- All components which are handled and/or deployed as individual Units shall be balanced, both in air and submerged to provide safe lifting and handling conditions.
- Skids shall be furnished with forklift pockets in accordance with lifting rules.
- Minor equipment (above 20 kg) shall be furnished with dedicated lift points for maintenance purposes, such as threaded eyebolts or safe sling attachment points as appropriate.
- Rotating lifting points such as threaded lift caps, swivels, etc. shall not be used on Units with weight above 50 kg. Welded pad eyes are required where possible.
- Running tools for operation down hole or inside marine risers and all wellhead tools for open sea operation shall be stored in canisters on separate or common transportation skids. The canisters shall be filled with preservation fluid during long term storage of such equipment. Proper equipment shall be included for drainage of fluid prior to offshore usage.
- Test skids shall have fully grated bases for safe operation offshore.
- Transportation baskets/skids with a design that require personnel to operate on or inside the Unit shall have fully grated bases.
- Test and transportation skids shall include a storage facility for lifting slings and protection covers/caps.

7.10.2 Design and certification requirements

Unless otherwise agreed, all assemblies shall be lifted in the workshop, from shore to vessel, between vessels or platforms or into the sea with use of one of the following methods in combination with a wire sling arrangement and/or purpose built spread to ensure a stable lift:

- Unit with purpose built integrated frame (such as pad eyes on the Unit)
- Purpose built lifting and transportation frame/box/container
- Standard Basket
- Standard Container.

CONTRACTOR shall demonstrate by appropriate calculation that any lifting device for offshore handling/installation has the capability to facilitate and ensure retrieval after decommissioning at the end of service life.

Prior to any design, fabrication, testing or documentation of any type of equipment to be lifted and appliances to be used during the lift, it is CONTRACTOR's responsibility to clearly define the intended use, frequency and lifting conditions for such equipment and identify applicable rules and regulations.



Before any lifting can take place, a certificate of compliance and Certificate for usage shall be issued.

The following three categories of lifting operations are addressed:

- Strictly regulated and defined number of lifts in controlled conditions onshore, offshore between vessels and offshore down to the seabed
- Repeated lifts onshore and offshore
- Running and retrieval of components from a drilling/workover vessel onto a Subsea Structure.

7.10.2.1 Limited number of controlled lifts

For Units with a strictly regulated and defined number of lifts such as X-Mas trees, structures, manifolds and other Units which will form part of a permanently installed Subsea Station, the following general requirements apply:

- Units above 10 tonnes - Design, fabrication, testing and documentation shall be in accordance with DNV Rules for planning and execution of Marine Operations (Ref. Note 1)
- Third party verification of purpose built slings and lifting gear is required
- Third party certification of the lifting gear for loads exceeding 50 tonnes is mandatory.
- Units below 10 tonnes - Design, fabrication, testing and documentation shall be in accordance with DNV Certification note 2.7-1 ([ISO 7531](#)), (ref. note 2).

Note 1: For offshore transportation, lifting and seabed installation of Structures, [GS STR 401](#).

Note 2: [DNV Certification note 2.7-1 \(ISO 7531\)](#) shall mean the complete note with exception of section 3.7, Prototype testing, and table 3.7, which shall be in accordance with [EN 10204](#) Certificate 3.1B.

7.10.2.2 Repeated lifts

For Units, which will be subjected to repeated lifts onshore and offshore, such as transportation baskets/frames, offshore containers and Units with purpose built integrated frame up to 25 tonnes, the following general requirements apply:

- Design, fabrication, testing, documentation and certification in accordance with [DNV Certification note 2.7-1 \(ISO 7531\)](#)
- CE marking and ILO certificate (ref. note 3).

Note 3: ILO certificate shall mean ILO Form No. 3.

7.10.2.3 Running/Retrieval from moon pool on surface vessel

Purpose built Units for running or retrieval of equipment to/from the seabed or a subsea structure, from a centrally positioned moon pool on a drilling/workover vessel or floating production unit shall be designed, fabricated and documented in accordance with [API 8C](#), "Drilling and Production Hoisting Equipment".

Subsea Installation/Retrieval from monohull surface vessel



Unless otherwise agreed for submerged lifts from monohull surface vessels, the following design conditions shall be assumed for design of lifting points, load bearing structures and slings (not applicable for Structures, ref. "Specification for Design of Subsea Structures"):

- Wave: Refer to Project particular specification
- Wave period: Refer to Project particular specification
- Hoisting speed: 1 m/sec
- Wave current: Refer to Project particular specification
- Dynamic response factor monohull: 1
- Stiffness factor of crane/wire: To be assessed by CONTRACTOR for the application

Due consideration shall be paid to dynamic loads resulting from lifting through the wave zone. Lifting out of the water shall assume structural items completely filled with water (valid for items designed to be flooded when submerged).

7.11 Identification and marking requirements

7.11.1 Nameplates

All equipment except drill string deployed running tools/components, shall be marked with the following information as a minimum:

- Description (name) of the component
- Part no.
- Serial no.
- CONTRACTOR'S name
- Year/month of fabrication
- Client
- Client Contract no.
- Tag/Item no.
- Weight
- CE certification data.

The information shall be clearly legible on a nameplate of corrosion resistant material, mechanically attached to the Unit, or hard stamped if necessary, in a position, which is easily accessible. In addition, tag or item number shall be painted on the Unit for omnidirectional identification.

Drill string deployed Units shall be hard stamped with the following information as a minimum:

- Part no.
- Serial no.
- Tag/Item no.
- Load rating.



All Units and lifting equipment shall be marked in accordance with European Community regulations with data/information/certificate relevant for lifting of the equipment.

7.11.2 ROV marking

Marking of Subsea Stations shall be in accordance with [ISO 13628-1](#), and the following requirements:

- Marking of submerged Units and functions shall be by means of “Aquasign” or similar marking system. Letter size shall be 50 mm
- ROV operable functions shall be marked with function identification and status O/S (Open/Shut, lock/unlock, etc.)
- Visual position indicators shall be legible using ROV deployed cameras
- All pressure containing parts shall be marked and documented in accordance with [API 6A](#) and [ASME B 31.3](#) as applicable
- All ROV marking on wellhead systems, Guidance systems and X-Mas tree systems shall be with black painted characters. If required, white colour may be used to ensure contrast and achieve proper identification
- Transportation devices, lifting points and sea fastening points shall be clearly marked with function and rating to prevent incorrect use.

7.11.3 Colour coding

Colour coding of Subsea Stations shall be in accordance with [ISO 13628-1](#).

7.12 Manufacturing and fabrication requirements

7.12.1 General

Components shall be manufactured in accordance with the requirements stated in the relevant COMPANY General Specifications.

All main components like bodies, bonnets, clamps, flanges, etc. shall be forged or cast to shape. Components machined from bar stock or plates are not permitted for pressure containing and/or load bearing equipment.

Attached non-pressurised components shall be compatible with the material to which they are to be attached. If such components are welded directly to pressure containing components or main load carrying parts, the requirements for the pressure containing components shall be adhered to.

7.12.2 Forgings

On forging with parallel production and annulus bores the material quality between the bores shall be verified by use of ultrasonic examination.

7.12.3 Weld overlay

Weld overlay shall be performed in accordance with the requirements of [GS PVV 614](#) and [API 6A](#). Dye penetrant examination shall be performed on 100% of the final overlay. Acceptance criteria shall be as defined by [API 6A](#), PSL3, except for sealing surfaces where no defects are accepted.

7.12.4 Welding

- Piping

Welding Procedures shall be qualified in accordance with ASME IX or EN 288.

Welding of duplex material shall be done in accordance with GS PVV 614. Welders and welding operators shall be qualified in accordance with ASME IX or EN 287. The qualification shall be carried out on the same type of base material as used in production.

- Structures

Welding of structures shall meet GS STR 301 requirements.

8. ROV/ROT Specific tools access requirements

According to ISO 13628-1 section 5.5.8.5.4, CONTRACTOR shall demonstrate access and efficient operability of all tools and all possible types of ROVs/ROTs which may intervene on the SPS.

This should be done first time during engineering activities with 3D modelling tools. A physical check shall be performed during Integration Testing and shallow water Testing.

9. Mechanical completion and preservation requirements

9.1 Preservation

The following general requirements for preservation of Units and Systems shall be applied:

- Valves and bores shall be properly dried and filled with suitable inhibitor to prevent corrosion of valve internals during storage.
- Protection shall be provided for all hydraulic stab couplers and electrical connectors to prevent mechanical damage and contamination during storage, testing and transportation.
- For winter storage, valve cavity shall be filled with glycol after testing. Water/glycol mixture shall withstand freezing at minus 30°C.
- Subsea Aquasign marking shall be protected with sunproof covers.

For further details on preservation and maintenance of preserved Unit, reference is made to COMPANY specification GS SPS 010.

9.2 Mechanical completion

Mechanical Completion (MC) requirements for Subsea Units and Systems are defined in GS SPS 011.

10. Test requirements

10.1 Introduction

All Units and Systems shall be subjected to a verification and acceptance testing programme in order to demonstrate that the design of the equipment, whether it is field proven or not, will satisfy all specified requirements and will perform satisfactorily in service, and that all Units and

Systems have been completed in accordance with the specifications prior to delivery. Dependent on equipment status, qualification tests of Units may also be required.

A comprehensive test program, covering the whole range from component and Unit integrity testing through functional and performance verification of all Units and Systems, shall be implemented. The test program shall be structured in such a manner that field installation and commissioning operations are simulated. The programme shall as a minimum include the following types of tests:

- Qualification and Verification Tests
- Unit Factory Acceptance Test (FAT)
- System FAT, Extended Factory Acceptance Test (EFAT)
- System Tests
- Integration Tests (IT)
- Shallow Water Test.

The benefit of specific shallow water tests should be assessed for unproven subsea installation techniques and procedures, or for techniques, which cannot be fully tested in air (e.g. acoustic based, buoyancy elements, IR light based systems, ROV held tools, etc.). CONTRACTOR shall document the needs and requirements for shallow water testing activities.

The Unit FAT shall be performed for each manufactured Unit. The number of System FAT/EFAT, System Tests and Integration Tests is to be defined in conjunction with delivery contractual schedule.

This section provides an outline description of the minimum requirements for the testing of Units and Systems. Detailed requirements are specified in each individual System and equipment specification.

10.2 General requirements

The tests shall be performed by use of the appropriate test facilities and test media required to demonstrate all functions of the system, including interfaces to other equipment.

All equipment shall be tested for the actual operation during field life.

The test program shall include the necessary system interface and stack-up tests to verify all the internal and external interfaces involved in the overall subsea system. All tool interfaces shall be tested by use of the appropriate tool.

The procedures shall reflect all the functional requirements specified for the different Systems and Units. The tests shall be performed with the relevant equipment and medium such as the correct hydraulic fluid, metal to metal seals, etc.

Care shall be taken to ensure that the testing does not cause deterioration or wear of the equipment, or affect the cleanliness level of hydraulic systems, at the point of delivery of the Units. Actual design life (number of cycles) shall not be reduced due to extensive operation of the System during fabrication and testing.

If deemed appropriate by CONTRACTOR, metal seals may be reused a maximum of three times.



Repeated stroking of valves to achieve sealing capability is not permitted. In the case where a valve does not seal during a test, the test shall be recorded as a failure, with identification of the reason for failure, and the corrective action required.

10.3 Test facilities

Test stands with facilities for testing of all equipment functions and pressure integrity shall be included for all components/systems as appropriate:

- Test skids may be combined units, designed and certified for use as transportation skids
- The stands shall be mounted on skid bases of fabricated steel with guideposts. The skids designed for offshore use shall include the necessary facilities for transportation, lifting, handling and storage offshore. See section 6.12 for lifting design requirements
- All stands shall include facilities for final preparation, including seal replacement, prior to installation subsea
- For testing of X-Mas tree Systems, two types of test stumps are required, one with only a dummy wellhead with the capability of receiving the PGB (onshore test stump), and one with a dummy wellhead and dummy PGB (offshore test stump).

10.4 Qualification and verification tests

All new Units and parts thereof, shall be qualified in accordance with the requirements of relevant ISO standards, API specifications, and COMPANY specifications.

New Systems, comprising qualified Units in combinations or configurations without previous field history, or a verification record, shall be verified by testing as above.

Modifications on a previously qualified product, which in COMPANY's opinion affects the performance of the product in the specified service conditions, shall undergo a new qualification test.

All such test procedures and programs shall be subjected to COMPANY approval prior to commencing the tests.

A design based on **API 6A** scaling principle, i.e. design similarity of an existing component regarding fit, form and function, will not be accepted. For all new designs, including new sizes and ratings of an existing design, completion of a successful qualification test program is required.

10.5 Unit Factory Acceptance Test (FAT)

A Factory Acceptance Test (FAT) of a Unit is the set of tests required to prove that the components of a Unit and the Unit itself, satisfy all specified functional and performance requirements. All factory acceptance tests for Units shall be performed in accordance with the requirements defined in **ISO 13628** and other relevant specifications.

For X-Mas trees and associated equipment in contact with produced fluids testing shall be performed in accordance with **ISO 13628-4**, PSL 3G section 12.3, unless otherwise agreed with COMPANY.

Unit FAT shall be performed at the Unit manufacturing site.

10.6 System FAT/Extended Factory Acceptance Test (EFAT)

A System FAT or Extended FAT shall include interface, pressure and functional tests of all Units within a System to prove that the System will perform satisfactorily in service and meet all specified system and detailed requirements.

The EFAT program shall demonstrate and document that the specified requirements are met with respect to:

- Functional and operational capabilities
- Interface configuration
- Operational envelopes
- Interfaces between Units and loose items
- Control and communication system sensitivity and noise immunity
- Pressure integrity
- Fluid and system cleanliness
- Atmospheric canisters pressure integrity (helium testing)
- Insulation resistance and conductance
- Resistance continuity to sacrificial anodes
- ROV access where applicable.

10.6.1 X-Mas tree system

For the X-Mas tree System a System FAT or EFAT shall include testing of interfaces and system performance between the following subsystems and associated Units:

- X-Mas tree subsystem
- PGB subsystem
- Wellhead subsystem
- Riser Units for Open Sea Configuration
- Riser Units for Marine Riser/BOP Configuration
- Satellite Well System
- Dummy wellheads if tie-back of existing exploration wells is envisaged.

All Units and Systems shall be subjected to a X-Mas tree System FAT prior to delivery in accordance with the following description. Detailed requirements are covered by the individual Unit and System specifications.

10.6.1.1 X-Mas tree system FAT

Stack-up, pressure, function, drift and interface test of the tree assembly and all associated caps on offshore test stump, or appropriate dummy template as required, using the WOCS. After delivery of the running tools and associated control systems to COMPANY, dummy tools and control systems shall be used to complete these tests.

10.6.1.2 PGB system FAT

Stack up, pressure, function and interface test of the relevant PGB versions, using the onshore test stump. This test shall be performed for all Units.

10.6.1.3 Wellhead system FAT

Stack-up, pressure and interface test of the complete wellhead system and PGB, including all relevant running tools, to prove system functionality, mechanical fitness, and interchangeability.

10.6.1.4 FAT of riser units for open sea configuration

Interface, drift and pressure test of selected riser Units for open sea configuration. This test shall be performed for each riser system prior to delivery, shall include interface check with all components of the riser, all handling and test tools, including spider and make-up tool, and umbilical clamps with dummy umbilical.

10.6.1.5 FAT of riser units for marine riser/BOP configuration

Interface, drift and pressure test of selected riser Units for open sea configuration. This test shall be performed for each riser system prior to delivery, and shall include interface checks with all components or the riser, all handling and test tools, including spider and make-up tool, and umbilical clamps with dummy umbilical.

10.6.2 Structures and manifold system

CONTRACTOR shall prepare relevant procedures and undertake a comprehensive system FAT programme at the fabrication site to demonstrate that the materials, subsystems or complete assembly at each level of testing meets or exceeds the specified requirements. All assemblies shall be mechanically complete prior to start of system FAT.

The system FAT shall include manifold module and pigging loop module replacement. Test with mock-up ROV with manipulator and mock-up BOP shall be included in the system FAT.

Single Unit FAT shall be performed on all components and assemblies produced to demonstrate that manufacture is according to shop drawings and manufacturing specifications. The same set of tests shall be repeated for each assembly produced. The Single Unit FAT shall min. include the following components and activities:

- FAT of valves at valve SUPPLIER site
- Operation of valves after installation in the piping system
- Function testing of hydraulic operated equipment
- Flushing and pressure testing of piping systems
- Pressure testing of connection between manifold and pigging loop module
- Barrier verification of isolation valves
- Pigging (pushing by water)
- Operation of hinged components
- Replacement of retrievable modules (e.g. manifold module, pigging loop module, protection covers or roof hatches, sea line protection, etc.)
- Guideline anchor attachment



- Lifting devices
- Installation rigging arrangements
- Locking mechanisms
- Electrical continuity
- Operation of hatches and protection covers
- Installation of and access to MCM and SAM
- Other relevant tests depending on CONTRACTOR'S design.

CONTRACTOR shall provide all required test equipment.

System FAT shall be performed on the complete main Unit for Subsea Structures to demonstrate the operability of the system, internal interfaces and that specified functional and performance requirements are met. System FAT shall be performed on a representative number of Units to reduce duplication of testing.

Relevant deformation (twisting) of the structures from uneven seabed conditions shall be accounted for in the FAT activities.

For all testing activities, precautions shall be taken to avoid spillage of fluids such as hydraulic oil, antifreeze or inhibited water. Any consequences of such spillage are CONTRACTOR'S responsibility.

10.6.3 Subsea production control system

To ensure correct performance on PCS equipment, the following requirements are applicable for all Units after FAT at manufacturing site:

- X-Mas tree located PCS equipment shall be function tested mounted on a X-Mas tree
- Template/manifold located PCS equipment shall be function tested mounted on a Template or manifold
- SDU located PCS equipment shall be function tested mounted on an SDU.

The tests shall include interface checks with all components including all handling, intervention and test tools. SCM shall be interface checked on at least two X-Mas trees. MCM and SAM shall be interface checked on at least two templates/manifolds. Retrievable equipment on SDU shall be interface checked on at least two SDU.

10.7 System test

10.7.1 General

The System Test shall verify and demonstrate the capability of the Systems to function and be operated as an integrated Subsea Station.

The ST shall verify equipment installation and operation by simulating actual conditions and by following the operational procedures.

All equipment shall have undergone FAT and System FAT/EFAT prior to System Testing.

System Test shall be performed indoors.

The detailed System Test Programme and test procedures shall be agreed with COMPANY in due time before start of testing.



The following outline requirements shall apply to the System Testing Site:

- Indoor test facility with space for template and/or manifold centre as applicable
- Compressed air and electrical power
- Crane with sufficient capacity covering the entire Template and/or manifold centre as applicable
- Storage area indoor min. 200 m²
- Storage area outdoor min. 1000 m²
- Access to telefax, E-mail and photocopying machines.

CONTRACTOR shall, upon COMPANY'S request perform the modifications and corrections of the Units in order to close out findings and punch list items from the System Test. The revised design shall be approved by COMPANY prior to implementation. All modifications and corrections shall be documented and registered in the MC documentation.

10.7.2 System test for Concept 1 (Template with Manifold)

The system test programme for Concept 1 shall as a minimum comprise the following main activities for each template-manifold, as applicable for the different types of Units:

10.7.2.1 General tasks

- Inspection of equipment received on site
- Equipment hook-up
- Photo and video recording of testing
- Foundation system/template verification test (connection and levelling where applicable)
- Manifold Testing
- Retrieval and reinstallation of Manifold Control Module and Subsea Accumulator Module when applicable
- PCS: performance verification test of all integrated system functions on the Manifold Module
- Installation of Pig Loop Module if applicable after tie-in and connection test
- Manifold pressure test with PLM installed after tie-in and connection test
- Fit test of protection caps and test caps.

10.7.2.2 X-Mas tree testing on template slot No. 1

- Installation of X-Mas tree onto dummy wellhead
- Retrieval and reinstallation of SCM and choke
- Stack-up test of X-Mas tree with running tools and dummy ROV with workover control system, ROV panel and workover control jumper
- Installation test of tree cap
- X-Mas tree to Manifold connection verification test

- Pressure test of X-Mas tree to Manifold connectors including production, service and small bore piping
- Functional and performance test of all integrated system functions on the X-Mas tree with WOCS
- Verification of all X-Mas tree override functions
- Any other activity required to ensure proper function and integrity between the wellhead, manifold module, foundation bottom structure, X-Mas tree equipment, and PCS.

10.7.2.3 X-Mas tree testing on all other template slot

At each template slot location, the following tests shall be carried out:

- Installation of X-Mas tree onto dummy wellhead
- Mating and pressure test of X-Mas tree to Manifold connectors including production, service and small bore piping
- Performance verification test of all integrated system functions on the X-Mas tree with the Production Control System.

Same tests as above shall be carried out on spare slots for off-Template wells.

10.7.2.4 Tie-in System

- Tie-in, connection and pull-out of dummy flowlines
- Tie-in, connection and pull-out of dummy integrated service umbilical
- Pressure test of connections
- Verification of all override functions
- Remove PLM if applicable and perform Tie-in at opposite side of template to verify linking of additional template in daisy chain.

10.7.2.5 Production control system

- Function testing of X-Mas tree and Manifold Module via SCM and MCM
- Verify integrity of PCS and interfaces to all interfacing equipment, including additional sensors from other contracts, X-Mas tree, Manifold and topside platform/vessel control systems
- Sensitivity testing varying key parameters and monitoring system performance and limits of operation.

10.7.3 System test for Concept 2 (manifold/individual well)

The system test programme for Concept 2 shall as a minimum comprise the following main activities:

10.7.3.1 General tasks

- Inspection of equipment received on site
- Equipment hook-up
- Photo and video recording of the testing.

10.7.3.2 Manifold centres

- Installation and retrieval of guideposts
- Retrieval and reinstallation of Manifold Control Module and Subsea Accumulator Package
- Performance and verification test with PCS of all integrated system functions on the Manifold
- Fit test of protection caps and test caps
- Tie-in, connection and pull-out of dummy main and infield flowlines
- Tie-in, connection and pull-out of dummy main and infield service umbilical
- Pressure test of connections
- Verification of all override functions.

10.7.3.3 Tie-in system

- Tie-in, connection and pull-out of dummy flowlines and production jumper
- Tie-in, connection and pull-out of dummy integrated service umbilical
- Installation and connection of X-Mas tree to manifold jumper
- Pressure test of connections.

10.7.3.4 Cluster/Satellite wells

The following tests shall be carried out for all cluster/satellite wells:

- Installation of X-Mas tree onto dummy wellhead
- Pressure test of all connectors with the bores pressurised
- Performance and verification test with PCS of all integrated system functions on the X-Mas tree.

The following tests shall be carried out for one cluster/satellite well:

- Stack-up test of X-Mas tree with running tools
- Retrieval and reinstallation of SCM and choke
- Installation of tree cap
- Verification of all X-Mas tree and manifold override functions.

10.7.3.5 Production control system

- Function testing of X-Mas tree and Manifold Module via SCM and MCM
- Verify integrity of PCS and interfaces to all interfacing equipment, including additional sensors from other contracts, X-Mas tree, Manifold and topside platform/vessel control systems
- Sensitivity testing varying key parameters and monitoring system performance and limits of operation.

10.7.4 System test for Concepts 3 and 4

The system test programme for Concepts 3 and 4 shall as a minimum comprise the following main activities as applicable for the different types of Units:

10.7.4.1 General tasks

- Inspection of equipment received on site
- Equipment hook-up
- Photo and video recording of the testing.

10.7.4.2 Satellite wells

The following tests shall be carried out for all satellite wells:

- Installation of X-Mas tree onto dummy wellhead
- Pressure test of all connectors with the bores pressurised
- Production Control System testing verifying performance of all integrated system functions on the X-Mas tree
- Pressure test of connections.

The following tests shall be carried out for one satellite well:

- Stack-up test of X-Mas tree with running tools
- Retrieval and reinstallation of SCM and choke
- Installation of tree cap
- Verification of all override functions.

10.7.4.3 Tie-in system

- Tie-in, connection and pull-out of dummy jumper
- Tie-in, connection and pull-out of dummy integrated service umbilical if applicable
- Installation of (dummy) jumper from SDU if applicable
- Pressure test of connections.

10.7.4.4 Production control system

- Function testing of X-Mas tree via SCM, SDU and jumpers
- Verify integrity of PCS and interfaces to all interfacing equipment, including additional sensors from other contracts, X-Mas tree and topside platform/vessel control systems
- Sensitivity testing by varying key parameters and monitoring system performance and limits of operation.

10.8 Integration Tests (IT)

The objective of the Integration Tests (IT) is to verify all external interfaces between Systems and units supplied by CONTRACTOR and systems supplied by different Contracts, such as interfaces with flowlines, umbilicals, ROV and Dummy BOP.

The Integration Test programme shall include:

- ROV access check with dummy ROV and all relevant tools
- X-Mas tree System stack-up test with dummy BOP
- Tie-in of flowline
- Tie-in of service umbilical
- Function test of all valves and monitoring functions at actual location
- Any other activity to ensure proper fit, function and integrity between the Subsea Station and external interfaces (equipment and services) as required.

Actual field procedures and conditions shall be simulated to the extent feasible. This shall include simulation of conditions and operations such as pull-in and connection of flowline/umbilical with actual stiffness and back tension, operation of ROV functions using full scale models to demonstrate access to the function, and capability to observe position indicator with camera, etc. CONTRACTOR shall organise photo and video recording of testing activities.

10.9 Shallow water test

The objective if the shallow water test is to:

- Test all equipment which cannot be tested in air such as IR light based measurement systems, acoustics based systems, etc.
- Verify the actual ROV access capability and readability of equipment markings by ROV
- Verify the efficiency of buoyancy elements and check that subsea equipment is properly balanced
- Optimise the offshore installation procedures
- Familiarise offshore personnel with handling of equipment to promote efficiency and safety in installation and operation of subsea systems.

The shallow water test programme shall include as a minimum:

- Running and retrieving X-Mas tree system
- Making up of connection to between tree and manifold
- Running and retrieving control POD and choke valve insert
- Running of ROT system
- Interface accessibility of functional tests by use of ROV, including ROV installation tasks
- Testing of back up system such as manual overrides.

CONTRACTOR shall organise photo and video recording of the shallow water test activities.