



Exploration & Production

GENERAL SPECIFICATION

Drilling & Wells

GS EP FP 412

Workover Subsea Completion Systems for Horizontal Tree

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1. Scope

This technical specification is applicable to Workover/Completion systems for all the wells equipped with a Horizontal Christmas Tree. It defines the functional requirements to Workover/Completion equipment with associated control systems and umbilicals required to install the various Units and to perform Workover on Subsea Stations using the same type of drilling unit later on during the field life. The various running tools, such as Tree and Tubing Hanger Running Tools are described within the respective tree system specifications.

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 technical specification is supplementary to document **GS EP SPS 001**, and shall therefore be read in conjunction with said document and the other COMPANY specifications and standards identified therein.

The Workover/Completion System with all individual Units shall comply with all relevant statutory requirements and specifications as well as all relevant ISO, API and other referenced standards, unless otherwise stated by COMPANY.

Standards

Reference	Title
ISO 13628	Petroleum and Natural Gas Industries - Design and operation of subsea production systems - Part 1, General requirements and recommendations - Part 4, Subsea Wellhead and Tree Equipment
ISO 10423	Petroleum and Natural Gas Industries – Drilling and Production Equipment – Wellhead and Christmas Tree Equipment Second Edition
ISO 898	Mechanical Properties of fasteners made of carbon steel and alloy steel - Part I Bolts, screws and studs with specified property classes – coarse thread and fine pitch thread
NAS 1638	Cleanliness Requirements of Parts Used in Hydraulic Systems
NACE MR-0175 / ISO 15156	Material Requirements. Sulphide Stress Cracking Resistant, Metallic Material for Oil Field Equipment
ASME	Boiler and Pressure Vessel Code
SAE AS 4059 E	Cleanliness classification for Hydraulic fluids
SAE J 517	Hydraulic Hoses
SAE J 343	Test and Procedures for SAE 100R series hydraulic hoses and assemblies



Professional Documents

Reference	Title
API SPEC 6A	Specification for Wellhead and Xmas Tree Equipment
API SPEC 8C	Drilling and Production Hoisting Equipment
API SPEC 16A	Specification for Drill Through Equipment
API SPEC 16D	Control Systems for Drilling Well Control
API SPEC 17D	Specification for Subsea Wellhead and Xmas Tree Equipment
API SPEC 5 CT	Specification for Casing and Tubing
API RP 17G	Recommended Practice for Design and Operation of Completion/Workover Riser Systems
API RP 17H	ROV Interfaces with Subsea Equipment
API RP 16 Q	Design and Operation of Marine Drilling Riser System

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	



Total General Specifications

Reference	Title
GS EP SPS 001	Design philosophy and requirements for subsea systems
GS EP SPS 019	Subsea Production Control System
GS EP SPS 021	Subsea mateable electrical/optical connectors
GS EP SPS 022	Environmental testing of Subsea Electronics
GS EP SPS 023	Cleaning and Flushing of Hydraulic Systems
GS EP FP 411	Subsea Horizontal Christmas Tree system

Other equivalent and recognized standards not referenced above may be used if agreed by Company.

3. Introduction

3.1 Responsibility

It is the responsibility of anyone who supplies equipment to this specification to ensure and document compliance with the requirements defined by this specification, and other relevant standards and statutory requirements. Deviations from any of the requirements defined herein shall be clearly identified and treated as non-conformance in accordance with relevant Company procedures.

In case of discrepancy between standards and / or specifications, the most stringent shall apply unless otherwise specified by the Company.

3.2 Abbreviations

The following abbreviations are used in the document:

AMV	Annulus Master Valve
AWV	Annulus Wing Valve
BOP	Blowout Preventer
CIV	Chemical Injection Valve
EQD	Emergency Quick Disconnect
ESD	Emergency Shut Down
FAI	Fail As Is
FSC	Fail safe close
HP	High Pressure
HXT	Horizontal Christmas Tree
HPU	Hydraulic Power Unit
ID	Inside Diameter
ITC	Internal Tree Cap



LMRP	Lower Marine Rise Package
LP	Low Pressure
MIV	Methanol Injection Valve
MQC	Multi Quick Connection
NPT	Non Productive Time
OD	Outside Diameter
PCS	Production Control System
PCV	Production Choke Valve
PMV	Production Master Valve
PSD	Production Shut-Down
PWV	Production Wing Valve
RCM	Remote Control Module
ROV	Remote Operated Vehicle
SCM	Subsea Control Module
SCSSV	Sub surface safety valve
SLV	Service Line Valve
SPWV	Surface Production Wing Valve
SSTT	Sub Sea Test Tree
STT	Surface Test Tree
TCTV	Tree Cap Test Valve
TH	Tubing Hanger
THRT	Tubing Hanger Running Tool
UPS	Uninterrupted Power Supply
WOCS	Workover Control System

3.3 Documents

Documents : GS EP SPS 019, GS EP SPS 021, GS EP SPS 022, GS EP SPS 023, GS EP FP 411, ISO 13628, ISO 10423, ISO 898, NAS 1638, NACE MR-0175 / ISO 15156, ASME, SAE , S , 4059 E, SAE J 517, SAE J 343, API SPEC 6A, API SPEC 8C, API SPEC 16A, API SPEC 16D, API SPEC 17D, API SPEC 5 CT, API RP 17G, API RP 17H, API RP 16 Q are an integral part of this document.

4. System Description

4.1 Workover/Completion (WO/C) system overview

The Workover/Completion (WO/C) system comprises all equipment and associated control systems required to install the various units.



The WO/C systems shall be configured to cover the following main modes of operation:

- Initial completion installation (TH + completion string) and well clean up
- Installation or retrieval of the ITC with the completion riser with or without SSTT
- Installation or retrieval of the ITC with the drill pipe string
- Installation or retrieval of the Horizontal Christmas Tree with drill pipe string
- Major workover on same wells later on during the field life using the same type of drilling rig, BOP and riser.

The Workover/Completion systems covered by this specification, typically comprise the following main Units:

- Slick joint
- Subsea Test Tree (SSTT)
- Shear sub
- Retainer Valve
- Riser Joints
- Lubricator Valves (2)
- Landing joint
- Riser sealing mandrel
- Surface Test Tree (STT)
- Kelly cock assembly
- Spider, Handling and Make-up Tools

5. Workover/Completion running string systems

5.1 Introduction

The following sections define the requirements for all Units comprising Workover/Completion systems for Horizontal Christmas Trees. The different modes of operation with overall functional and operational requirements together with the corresponding well control requirements are defined.

5.2 Overall functional and operational requirements

The WO/C string shall be configured to cover all modes of operation stipulated in section 4, System Description.

The WO/C string shall include the necessary equipment and functionality to allow safe and efficient performance of the operations.

The WO/C string shall provide a pressure containing conduit for well bore fluids and smooth passage of the necessary well bore tools and equipment between the tubing hanger or ITC and the surface vessel.



The WO/C string shall be designed to facilitate all operations required to install/retrieve the TH, the ITC, the TH Production bore isolation sleeve, the TH and ITC protection sleeve and associated running tools for plugs/sleeves.

The WO/C string shall include, as a minimum, a valve configuration as follow to provide safe well control.

Valve	Failure Mode
2 Lubricator Valves (LV)	FAI
Retainer Valve (RV)	FSC
SSTT Upper Valve (SSTTUV)	FSC
SSTT Lower Valve (SSTTLV)	FSC

A nitrogen injection sub and / or chemical injection sub may be required.

The WO/C string shall include the following main equipment:

1. A slick joint below the SSTT, connected to the THRT, to allow isolation of the annulus using BOP rams.
2. A SSTT with the necessary valves to allow safe isolation of the well bore even with wireline or coiled tubing or braided coiled tubing in the well.
3. A quick disconnect point above the SSTT, allowing for disconnection/re-connection of the riser string with independent primary and secondary methods for disconnection.
4. A shear sub designed to enable cutting of the running string above the SSTT and SSTT disconnection point, with a BOP shear ram in the event of failure of both primary and secondary disconnect systems. It shall be designed to be shearable with the type of BOP mentioned in Drilling rig specification.
5. A Subsea retainer valve to isolate the riser at the bottom end in the event of a disconnection in order to prevent fluid from the well bore to enter into the marine riser and pollution to the environment.
6. A transition joint to provide a link between the lower tools and the riser control module.
7. A riser control module to perform the completion/workover functions through an electro-hydraulic multiplex control system (project specific).
8. A monobore riser with the necessary umbilical clamped on it.
9. Two subsea lubricator valves to provide pressure containment close to the surface for deployment of wireline tool strings.
10. A Kelly Cock Assembly for connection to the riser at any time during running/retrieving of the landing string.
11. A swivel and a Surface Test Tree (STT) with the necessary functions to allow isolation of the well bore and access for wireline and coiled tubing.

All hydraulic and electric functions running inside the drilling riser and BOP shall be controlled from the WOCS.



The equipment provided shall allow for installing or retrieving the ITC using WO/C riser with or without the SSTT.

Two options shall be proposed for the monobore riser:

- Monobore riser used only with the marine riser and BOP package. Riser joints could be in this case made of tubing (or casing) joints with premium threads.
- Riser joints designed for “open sea operations” and to be run inside the marine riser and BOP package.

The final choice shall be Project Group decision. Contractual aspect and economics shall be part of the decision.

5.3 General functional and design requirements for the WO/C running string

The following general functional and design requirements are applicable to the entire Workover/Completion String or the relevant parts of it:

1. The entire Workover/Completion String shall be capable of supporting the full weight of the tubing hanger system and the production tubing string, and shall have adequate strength to allow retrieval of the tubing string with sufficient force to overcome total string weight and maximum expected downhole friction + 50 metric tons. Minimum load capacity shall be homogeneous with the TH requirement (see Tubing hanger system/general requirements).
2. All equipment shall be rated to 10000 psi working pressure unless higher pressure rating is required.
3. All equipment shall withstand external hydrostatic pressure with atmospheric pressure inside.
4. The WO/C string shall be designed to be deployed through an 18”3/4 ID BOP system and marine drilling riser.
5. The Sub Sea Test Tree (SSTT) shall be designed to facilitate well control and safe re-entry in the event of an emergency disconnection, even with wireline or coiled tubing or braided coiled tubing in the well, and isolate the well bore.
6. The STT shall be designed to allow communication with the well bore, through surface valve control. It shall allow work over operations inside the wells, by deployment of wireline or coiled tubing through the top of the STT.
7. The entire WO/C string and its components shall be designed to allow unhindered passage of all components required to perform well intervention and to establish the necessary well barriers, including wireline and coiled tubing tool strings.
8. All valves in the vertical bores shall be designed to allow snag free operation of wireline and coiled tubing equipment through the valves, and shall include facilities to ensure correct alignment of the valve bores relative to the bore of the landing string. The valve bore closing elements shall have beveled edges to reduce the risk of snagging.
9. The components of the WO/C strings shall be designed to tolerate the most severe combinations of coincidental loads from internal and external pressures, temperatures, compression from the BOP rams/annular preventers, and axial riser loads for all conditions during handling, transportation, as well as normal operations and contingency operations.



10. Riser systems and umbilicals shall be analyzed, designed and qualified for the requested design and operating conditions. Calculation modes shall be agreed by Company.
11. The riser components including the lubricator valves shall be designed with beveled profiles for snag free running inside a marine drilling riser, with the umbilical bundles required to operate the landing string functions, attached to it.
12. All components of the WO/C string (including the TH with THRT) shall be designed to be run through a standard 18-3/4" BOP stack with marine riser and flex joint, and shall be capable of snag free passage with the flex joint deflected to an angle of 3°.
13. The THRT and lower landing string including the adapter above the retainer valve shall be designed for assembly/disassembly on land and transportation offshore as one unit.

5.4 Workover/Completion Units

5.4.1 Slick joint

The slick joint shall provide:

A slick section for isolation of the annulus with BOP rams, and be designed in such a way it permits to apply pressure test on TH seals.

A lower connection to the Tubing Hanger Running Tool, and a upper connection to the SSTT.

The slick joint shall consist of 10 3/4" OD pipe section with integrated control lines for the THRT and TH functions.

For a correct spacing out inside the BOP stack, the slick joint length complies with:

- The free shear rams closure above SSTT after disconnection
- Shearing of the shear sub without damaging the EQD and fishing of the remaining part.

This spacing shall be checked precisely for each rig after contract award.

As the ITC and the TH shall be run with the WOCS system, different size and length of slick joints shall be provided to cope with all the possible configurations.

5.4.2 Subsea Test Tree (SSTT)

The SSTT may be part of the scope of supply and if this is the case the equipment and interfaces with other equipment shall be under the SUPPLIER's responsibility.

The Subsea Test Tree (SSTT) shall provide a facility to isolate the well above the tubing hanger in accordance with the following design requirements:

1. SSTT assembly Shear and Seal requirements:

- Cut slick line without hydraulic close assist.
- Cut 2", 0.125" wall thickness coiled tubing with electric wire inside with hydraulic close assist. The valve shall be capable of sealing after the cutting operation.
- Seal against design pressure from above for testing of the EQD connector.
- Pump through capability for bull heading of well or alternative pumping procedure using the drilling BOP kill line and Christmas Tree annulus and production outlets functionalities.



- All valves shall be capable of opening closing and sealing with atmospheric pressure or design pressure in the bore.
- 2. All valves shall be capable of closing in flowing well conditions.
- 3. The SSTT shall include 2 operated valves in accordance with the previous specifications. One of them at least shall be a ball valve.
- 4. The SSTT shall include facilities for injection of methanol and / or chemicals into the well bore between the valves. The injection point shall include two barriers against back flow.
- 5. The SSTT shall allow for complete flushing and cleaning of the hydraulic paths.
- 6. The SSTT shall include an integrated connector to facilitate quick disconnection in the event of an emergency situation, and re-entry afterwards of the running string in accordance with the following requirements:
 - The connector shall have an actively pressurized latch/unlatch function with connector mechanism and hydraulic connections capable of repeated disconnects and re-entries without the need for retrieval of the riser to surface for inspection/maintenance.
 - The connector shall be designed to prevent for non programmed disconnection.
 - Complete disconnection of the landing string above the SSTT shall be achieved within 15 sec. from activation at surface.
 - It shall be possible to disconnect with the pressurized control lines. The hydraulic functions shall be designed with due consideration to U-tube effects and contamination of the hydraulic system (minimize water ingress).
 - The control lines below the disconnection point shall be vented without unlocking the TH and THRT.
 - It shall be possible to reconnect without unlocking the TH and THRT.
 - A secondary independent disconnect facility shall be included.
 - There shall be a facility to determine vertical position of the landing string during re-entry for space-out of the riser by tagging on a BOP ram.
 - The connector shall be designed with the objective of preventing settlement of debris in areas with critical influence on the SSTT functionality, such as hydraulic couplers etc.

5.4.3 Shear Sub

The landing string shall include a shear sub between the SSTT disconnection sub and the retainer valve. In case of emergency disconnection of the marine riser, it can be cut by the shear rams of the BOP stack.

As the workover/completion string shall be used for the tubing hanger and internal tree cap installation/retrieval with different rigs, the shear subs provided shall allow for shearing in all the configurations listed here above.

All shear sub shall fulfill the following requirements:

1. The shear sub shall have sufficient strength to tolerate maximum landing string tension and bending moment (up to 5° angle at the flex joint) in addition to internal pressure, be able to cut by BOP shear rams even with tool string inside like coil tubing.



2. The shear sub shall be design to get the Retainer Valve and RCM in the upper part of the BOP stack and ensure sealing of the bag preventer when used.
3. The system shall include a tool designed for removing the upper part of the EQD Connector and shear sub when the shear sub has been sheared.
4. Detailed analysis of the shear sub shall be performed and the design shall be optimized if required with respect to specific BOP shearing capacity.

5.4.4 Retainer Valve (RV)

A Retainer Valve is required at the lower part of the Workover/Completion string to avoid any release of fluid in case of disconnection.

The Retainer Valve lower connection shall interface with the shear sub.

The Retainer Valve upper connection shall interface with the transition joint.

The Retainer Valve shall provide a facility to prevent release of production fluid and/or gas into the marine riser. The following requirements shall be applied:

- The valve shall be capable of retaining fluid and gas in the WO/C riser at full working pressure.
- It shall not be possible to pump through the valve in closed position.

The retainer valve shall have a smooth outer housing allowing the BOP annular bag to close and seal over the valve body (if relevant).

There shall be a facility which vents automatically the volume between the SSTT and the retainer valve when the retainer valve is closed, prior to any disconnect.

5.4.5 Transition joint

The transition joint shall be located between the retainer valve and the riser control module.

The transition joint shall provide continuity of the hydraulic and electric lines between the riser control module and the retainer valve.

As the transition joint is part of the Workover/Completion System, it shall provide the continuity of the wellbore with all requirements listed here above. The design working pressure shall be 10000 psi.

The transition joint shall allow smooth outer surfaces allowing the BOP annular bag preventer to close and seal over the transition joint body. The maximum external pressure to be applied shall be 10000 psi.

The transition joint shall be designed to withstand all the pressure, tension, bending and fatigue loads in all operational situations listed here above. The maximum flex joint angle that shall be considered is 5°.

5.4.6 Riser Control Module

The Riser Control module is part of the Workover Completion control system. Its lower connection interfaces with the transition joint.

The Riser Control Module shall be located in the 21" drilling riser above the flex joint.



The Riser Control Module shall provide continuity to the wellbore with all requirements listed here above.

The Riser Control Module is connected to the tubing hanger umbilical. The connection between Riser Control Module an umbilical shall be easy to handle in surface and avoid snagging during running in or retrieving the Workover/completion string.

The Riser control Module components shall withstand the hydrostatic pressure of any fluid being used during completion phases.

The Riser Control Module shall resist to shocks and vibrations induced during installation and well cleaning operations.

In case of lost of hydraulic supply, the Riser Control Module shall provide hydraulic accumulation for three (3) complete disconnection sequences.

5.4.7 Lubricator valve

The WO/C system shall include two lubricator valves for use in the upper riser sections during wireline and coiled tubing operations in accordance with the following requirements:

- The lubricator valves shall allow killing of the well by pumping through the string with the valve in closed position.
- The lubricator valves shall be made up to one assembly and shipped offshore as one unit.
- The lubricator valves shall have their own umbilical.

5.4.8 Kelly Cock Assembly

The WO/C system shall include a Kelly Cock Assembly for isolation of the riser at any time during running or pulling the TH and completion string, in accordance with the following requirements:

- The Kelly Cock Assembly shall consist of an adapter from the WO/C riser to the kelly cock valve unit, with minimum 1 ft long neck for make-up with tongs, and a valve unit with connection consistent with drilling rig top drive connection. Shall be clearly specified after contract award.
- It shall have a pressure rating as per the WO/C system, and a minimum 3.5" ID.

The assembly shall be made up as one unit. There shall be a removable lifting device on the adapter body for rig floor handling. Overall length shall be minimized.

It shall be possible to connect a top drive and a side outlet to the top of the assembly.

Minimum tension load capacity shall be consistent with WO/C riser.

5.4.9 WO/C Riser Units

When connected together in a string the WO/C Riser Units shall act as an extension of the production bore from the tubing hanger or the ITC.

The WO/C riser shall be proposed on two options:

- Tubing (or casing) joints with premium connections
- Riser joints designed for "open sea operations" or run inside the marine riser and BOP package.



The WO/C riser units shall be 10000 psi working pressure. It shall be designed to withstand the external hydrostatic pressure with atmospheric pressure inside.

5.4.9.1 Tubing (or casing) joints option

Following general requirements for WO/C riser Units shall apply:

The riser system shall include connections designed for quick and easy make-up and break-out.

The riser connections shall be designed for operation with gas in the WO/C riser, and shall remain gas tight under all combinations of tensile and bending loads.

The riser joints shall be designed with a smooth through bore with no internal restrictions or recesses.

The riser connections shall be designed for frequent make-up/break-out. Threaded integral connections shall have sufficient material to allow for minimum one re-cut of the threads.

The hang-off equipment, riser spider bushing/slips, shall be designed to allow the entire completion string to be supported.

The riser shall include a set of umbilical clamps, designed to be clamped to the running string. The clamps shall be positioned at a spacing which ensures that the wet umbilical is properly secured to the riser without slipping during any running/retrieval operation, and that it is protected against abrasion inside the marine riser. The umbilical clamps shall be designed to avoid snagging in the spider and inside the marine riser.

Loose parts on the connectors and umbilical clamps, or any parts which can break loose or require use of hand tools etc. shall be avoided to prevent accidental dropping into the well during running/retrieval of the riser string.

The system shall be designed for racking in the derrick in suitable running stands, according to Drilling rig specification chapter. Pup joints of 5', 10', 15' and 20' shall be included to allow appropriate space-out of the landing string.

5.4.9.2 Riser joints designed for “open sea operations” or run inside the marine riser and BOP package

Following general requirements for WO/C riser Units shall apply:

The riser system shall include connectors and seals designed for quick and easy make-up and break-out.

Seal surfaces shall be inlaid with corrosion resistant material.

The riser connections shall be designed for operation with gas in the WO/C riser, and shall remain gas tight under all combinations of tensile and bending loads.

The riser joints shall be designed with a smooth through bore with no internal restrictions or recesses.

The riser connectors shall be designed for frequent make-up/break-out. Threaded integral connections shall have sufficient material to allow for minimum one re-cut of the threads.

The hang-off equipment, riser spider bushing/slips, shall be designed to allow the entire completion string to be supported.

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secured to the riser without slipping during any running/retrieval operation, and that it is protected against abrasion inside the marine riser. The umbilical clamps shall be designed to avoid snagging in the spider and inside the marine riser.

Loose parts on the connectors and umbilical clamps, or any parts which can break loose or require use of hand tools etc. shall be avoided to prevent accidental dropping into the well during running/retrieval of the riser string.

The system shall be designed for racking in the derrick in suitable running stands, according to Drilling rig specification chapter. Pup joints of 5', 10', 15' and 20' shall be included to allow appropriate space-out of the landing string.

The inner of the riser joints shall be designed and manufactured to prevent corrosion with completion / work over fluids and sea water.

5.4.10 Landing Joint

The Landing Joint shall include a smooth cased section for centralization through the spider and protection of the riser/umbilical at the surface vessel interface during installation operations. The length of the landing joint shall accommodate the relative motions between the vessel and the joint caused by heave and tidal motion, draw-down as a result of lateral deflection of the riser, and final orientation/landing of the tubing hanger. The length of the Landing Joint, shall be agreed specifically for each drilling rig.

5.4.11 Riser sealing mandrel

In case of a failure of any landing string component inducing a leak of the produced effluent inside the drilling riser it shall permit to divert this effluent through one of the drilling rig diverter lines.

It shall be integrated to the landing joint, located at the drilling rig diverter level, have a length compatible with the rig movement due to the heave and tide.

It shall provide an efficient sealing around the landing joint and umbilicals and shall be activated by the closure of the drilling rig diverter.

Working pressure: 500 psi

5.4.12 Surface Test Tree (STT)

The Surface Test Tree (STT) shall provide a facility for well control and suspension of the riser by means of elevator. The STT shall include the necessary valves to facilitate all necessary well control and clean up actions and access the well bore by means of wireline and coiled tubing tool strings.

Valve	Size/WP	Failure Mode
Surface Production Master Valve (SPMV)	7 1/16" / 10K	Manual
Surface Production Wing Valve (SPWV)	4 1/16" / 10K	FSC
Surface Production Kill Valve (SPKV)	3 1/16" / 10K	FAI
Methanol Injection Valve (MIV)	1" / 10K	Manual
Production Swab Valve (PSV)	7 1/16" / 10K	Manual



The STT shall include a valve arrangement as listed above and comply with the following requirements:

All valves shall have position indicators clearly legible from the rig floor.

The MIV shall be a solid block type.

The STT shall include a swivel.

The STT shall include a protection frame with a facility to ease installation of the production hose and a platform suitable for safe operation of manual valves.

Production wing valve shall close by means of spring return within 10 seconds in case of a Production Shut-Down (PSD) or Emergency Shut-Down (ESD).

The STT shall include a re-entry adapter, usually a Quick Union type for slick line or coil tubing equipment connection.

The STT shall include a profile suitable for suspension of the entire running string on the rig draw works, using bails with shackles and an appropriate casing elevator.

The STT lower connector shall be a quick connector type, to be connected to the top of the landing joint.

The STT shall have production and kill outlets with connectors facing down.

The kill side shall be prepared for a WECCO Fig. 1502 hose connection. This can be done by bolting a different type x-overs to a 3 1/8" stud outlet.

The production outlet shall be 4-1/16" / 10Ksi stud. This provides the flexibility to cross over to a clamp hub profile as required.

5.4.13 Riser Spider, Tools and Auxiliary Units

The riser system shall include all necessary tools and auxiliary equipment to provide safe and efficient handling of individual riser joints and entire riser strings, racking in the derrick, make up of riser joints as well as lifting and transportation onshore and offshore.

5.4.13.1 Spider

The spider shall be designed to provide support/centralization and hang off for the riser joints during running and make-up. It shall be simple and rugged and meet the following requirements:

The spider shall be designed for installation in a standard rotary table guide bushing (see rig specifications).

The spider shall be designed to accommodate the loads from the complete riser and tubing string.

The spider shall include means to prevent rotation relative to the rotary table.

The spider assembly shall be split to allow installation with the riser in the rotary. Loose parts or any parts which can break loose, or require use of hand tools, etc. which can accidentally be dropped into the well, shall be avoided.

The spider beams shall be power operated with manual back up, and be stable in both end positions with respect to gravitational forces and dynamic actions caused by the vessel.



The beam design shall provide centralization of riser, and shall allow rotation of the riser within its design limits, without causing undue bending moments to riser.

The spider shall include a guide arrangement suspended in the rotary for lateral guidance through the rotary/diverter area.

The spider design shall give a smooth passageway for the riser (or lubricator valves), umbilical and clamp with the beams in retracted position, i.e. prevent snagging or damage of umbilical/riser during running both ways. The design shall give adequate protection of the umbilical

5.4.13.2 Riser make-up tool

Riser connections requiring torque application shall be made up by use of a dedicated powered tool, designed to provide safe and efficient make-up and breakout of all relevant riser Units, in accordance with the following requirements:

- The tool shall be self-contained, with only a single line to the external power source.
- The tool shall be designed with the objective of achieving minimum time for make-up/break-out.
- The output torque shall be adjustable, and torque reaction between the connections shall be taken up internally in the tool.
- The tool shall be capable of making up and breaking out connections with the riser supported in the spider in any orientation.
- The tool shall be designed to avoid damage to the riser joints and equipment.

Ergonomic design principles shall be applied on all handling and operation of the tool to maximize personnel safety. A safety analysis shall be performed to qualify the design and identify the need for back-up of functions, failure of components, accidental situations for personnel, warning signs, etc.

The tool shall include facilities for lifting/handling and transportation in both onshore and offshore conditions.

5.4.14 WO/C Riser Analysis

The WO/C riser system and all of its load bearing components shall be designed in accordance with design analysis based on accepted principles of static and dynamic analysis, strength of materials, fatigue analysis, etc. taking into account environmental conditions, vessel response characteristics as well as all relevant operational requirements. The following typical design cases shall be evaluated:

- Handling/Transportation/Racking
- Running/Retrieval
- Running/Retrieval of landing string through marine BOP with flex joint angle of 3°
- Landing/Latching/Unlatching
- Over pull to test bottom connection
- In-service pressure test
- Normal operating conditions, connected



- Subsea shut-in, connected
- Emergency disconnect
- Over pull to retrieve tubing hanger and tubing

Design cases for open water shall be evaluated for the dedicated WO/C riser type.

Prior to conduct the riser analysis, the following design criterion shall be prepared and issued for Company review and acceptance:

- analysis approach
- scope of work
- method and tools for analysis
- load cases
- acceptance criteria

6. Workover control system

6.1 Introduction

This section describes the requirements for Workover Control Systems (WOCS) for Horizontal Tree Systems to perform operations on the different mode described in the WO/C system overview chapter.

6.2 Overall functional and operational requirements

The WOCS shall provide the necessary functionality to control all functions on the workover/completion equipment including tools and systems to perform initial installation of the completion and tubing hanger system, the Christmas Tree system, and to perform any workover required in the life of a well. It shall include facilities to perform normal and emergency shutdown and disconnection of specified functions in automatic sequences upon activation from the surface facilities. The system shall be capable of controlling the tools and equipment for the following main operations:

- Installation/retrieval of the tubing hanger system
- Operation of landing string with isolation valves and disconnect facilities
- Running/retrieval of Christmas Tree using associated running tool(s)
- Installation and retrieval of the internal tree cap with the tubing hanger running tool
- Operation of Surface Test Tree (STT).

It shall include facilities to perform normal and emergency shutdown and disconnection in automatic sequences from the surface facilities.

It shall provide facilities to perform methanol injection in the STT and SSTT.

The Supplier shall be responsible for identification, engineering and provision of hardware and procedure for the SSTT and interfaces with Supplier's equipment.

6.2.1 Valve configuration and mode of operations

See in annex Production Flow Diagram (PFD) Drill through Horizontal Christmas Tree

Valve description	Operation mode		Production mode	
	Control	Failure	Control	Failure
Production Master Valve (PMV)	WOCS	FSC	PCS	FSC
Production Wing Valve (PWV)	WOCS	FSC	PCS	FSC
Production Choke Valve (PCV)	ROV	FAI	PCS	FAI
Annulus Master Valve (AMV)	WOCS	FSC	PCS	FSC
Annulus Wing Valve (AWV)	WOCS	FAI	PCS	FSC
Methanol Injection Valve (MIV)	WOCS	FSC	PCS	FSC
Service Line Valve (SLV)	WOCS	FSC	PCS	FSC
Tree Cap Test Valve (TCTV)	ROV	FAI	ROV	FAI
Chemical Injection Valve (CIV a,b,c)	ROV	FAI	PCS	FSC
Chemical Injection Valve (CIV d)	WOCS	FSC	PCS	FSC
Dosing Valve (FT)	ROV	FAI	ROV	FAI
Smart completion valves	ROV	FAI	ROV	FAI
Isolation valve for SCSSV	ROV	FAI	ROV	FAI
SCSSV Control	WOCS	FSC	PCS	FSC

6.2.2 Automatic shut-down and disconnect functions

The WO/C system shall include the necessary functions for automatic, sequential shutdown and disconnection of Units by activation from surface control panels.

- Production Shut Down (PSD) shall be achieved within 10 seconds from activation
- Emergency Shut Down (ESD) shall be achieved within 30 seconds from activation
- Emergency Quick Disconnect (EQD) shall be achieved within 60 seconds

Operational response time requirements for tree and tubing hanger landing string disconnection operations makes that an electro-hydraulic or multiplex control system shall be mandatory.

The following main functions shall as a minimum be included:

PSD	ESD	EQD
SPWV	SPWV	SPWV
	AMV	AMV
	PMV	PMV
	AWV	AWV
	SSTT Lower Valve	SSTT Lower Valve
	SSTT Upper Valve	RV
	SCSSV	SSTT Upper Valve
		SCSSV
		UNLATCH

In addition the following requirements shall be applied:

- The Shear and Seal Valve shall be closed before EQD unlatch starts.
- The shut down times shall be achieved with both zero and Design Pressure in the bores.
- The WOCS shall be designed to immediately vent all umbilical functions which may spill hydraulic oil into the marine riser or the environment in the event of a regular EQD, or shearing of the LS with the marine BOP and disconnection of the riser.

For the Tree installation mode, emergency quick disconnection shall be provided at the Tree running tool:

- A separate ESD function and an emergency disconnect function shall be dedicated to the tubing hanger installation and workover mode, for the landing string:
 - On operation of the ESD function, the total sequenced closure of the landing string valves (both SSTT valves, retainer valve) and the surface tree SPWD valve shall be performed, as well as the SCSSV.
 - On operation of the emergency disconnect function, the above ESD function shall operate, the EQD of the SSTT shall be unlatched.
 - The workover control umbilical for the tree shall have automatic disconnection plate at the LMRP level.
- Both ESD's and emergency disconnect functions shall be operable during the tubing hanger installation and workover mode.

For shut-down and emergency disconnections, the following time shall be achieved:

- Emergency shutdown shall be achieved within 30 seconds in both tubing hanger installation mode and tree installation or drilling mode.
- Emergency quick disconnect shall be achieved within 60 seconds in both tubing hanger installation mode and tree installation or drilling mode.



6.3 Functional and Design Requirements for the WOCS

The work over control system shall incorporate the following units:

- Master control unit, including the hydraulic power unit and the master control panels (tree and tubing hanger functions, shut down and emergency functions, power unit functions)
- Alarm, shut down and emergency panels
- Remote control panels
- Remote video for ROV operations
- Work over umbilicals and jumpers
- Umbilical winches
- MQC plates and BOP jumper
- Umbilical sheaves
- Auxiliary equipment

The following general requirements shall be applied:

- The work over control system shall be design to operate in hazardous areas, zone 2. It shall also be fabricated for operation on an open deck area, exposed to all weather conditions.
- Maximum acceptable weight for each Unit is 40 metric tons
- A complete hydraulic, electric, and software redundancy is required throughout the whole system.
- For drilling and completion activities, BOP control system and hydraulic supply, and work over control system and hydraulic supply shall be totally independent.
- The work over control system shall be designed for connection to the drilling unit electrical power.
- A UPS unit is required enabling an emergency electric supply of 1 hour, in case of an electric shut down.
- The capacity of the hydraulic control system shall be designed to ensure that 3 repeated open and close sequences can be completed with the hydraulic supply shut down.
- Accuracy of pressure gauges and transmitters shall be $\pm 1\%$ of full scale, or better.
- Protective covers shall be provided for all external control panels, umbilical terminations and MQC plates to prevent damage and/or contamination of couplers during transportation and operation.
- The system shall include an ROV panel for mounting on the BOP with jumpers to the ROV panel on the HXT. The connection between the Lower Marine Riser Package and the BOP shall be an automatically operated stab plate, designed for easy re-entry.
- A panel shall be mounted on the drilling BOP with attached jumpers to the MQC connectors on the tree and subsea control module.
- In case of a disconnection (tree, landing string or tubing hanger), the hydraulic umbilical shall be designed to prevent sea water from surging in the line.



- Equipment shall be shock/vibration resistant to withstand normal transportation and rig movement.
- All units shall be skid mounted, designed and protected for offshore and onshore lifting and handling and shall be supplied with lugs for seafastening including transportation protection where necessary.
- All functions which may cause hazardous situations if actuated accidentally, or actuated in other than its normal operating mode or sequence, shall be protected by interlocks, automatic timed sequences and/or other means of disabling facilities, such as overlay panels and protective covers on push buttons. It shall be possible to override the interlock.

Functions to be protected shall as a minimum be:

- EQD Connector unlatch
- SSTT/EQD connector unlatch
- THRT unlatch
- TH unlatch

Note: There shall be no interlock between the Retainer valve and EQD connector.

6.3.1 Subsea control module and related tree piping

The subsea control module shall be mounted on the tree. It is tied up hydraulically and electrically to the production control system to perform the required functions during the production periods.

During installation/test while drilling/workover operation, electric and hydraulic communication from surface to the subsea control module (via the workover control umbilical) shall be set. The hydraulic supply from the production control system shall then be isolated. The workover control system shall also take control over sensors data electrical transmission.(three way ball valves are submitted to Project Group approval).

- The subsea control module shall be independently replaceable from the tree by ROV assisted means, through use of a cable running tool.
- A protection against falling objects, shall be installed for the subsea control module, without complexifying the retrieval operation (protection cover may be ROV installable/removable).
- The required hydraulic and electric piping/cabling shall be routed directly from the production control system connector or through the subsea control module to perform all the tree function (valve operation, injection, SCSSV, data monitoring, intelligent completion function).
- The required piping/cabling shall be routed to insure the work over system to get a full hold of the functions.
- The piping/cabling layout shall offer maximum protection from damage.
- The piping/cabling shall be strongly attached to the tree frame in order to avoid any damage due to vibrations and shocks during the complete life of the well.
- All hydraulic piping associated with permanently pressurized lines, LP/HP & chemical injection lines shall be continuous to minimize 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.

6.4 WOCS Units

6.4.1 MQC connectors and associated functions

The Christmas Tree shall be fitted with three MQC plates where the work-over control umbilical shall be connected, through the MQC plate, to perform the related remote functions in a work-over mode. The work-over control system (via the work-over control umbilical and the plates) takes the control upon the production control system.

- Tree installation plate. This plate shall allow the following tree remote functions to be operated:
 - Tree lower connector lock and unlock.
 - Connector pressure test or monitoring (direct line).

Remark: The SUPPLIER shall make sure that no other function than specified can be operated when the workover control umbilical is connected to the tree installation plate.

- Workover plate. This plate shall allow the following tree remote functions to be operated:
 - All remotely operated valves shall be operable (see table)
 - SCSSV control
 - Injection capabilities through the two chemical lines (for penetration function/pressure test)
 - Testing capabilities through the two spare 1/4" x10000 psi hydraulic lines for intelligent completion
 - Tree Cap Test Valve line for pressure test and monitoring (direct line)
 - Tree Cap P&T sensors
 - Electrical sensor monitoring if the plate incorporates the electric connection. If not these functions shall be insured by flying leads.

Remark: The Supplier shall make sure that the tree installation function cannot be operated when the work over control umbilical is connected to the Workover plate.

- Parking plate. This plate does not operate any function of the tree. It allows to park the work-over control umbilical connector if required or park protective plates for the use of both other plates.
- A ROV operated or automatic mean for completely isolating the subsea control module from the production control during installation, drilling, completion and workover operation shall be available on the tree. This function can be made through the MQC plate.
- The MQC connection shall be rated for a working pressure equal to the relevant hydraulic umbilicals.
- The connection of the MQC plate shall include a simple mechanical locking arrangement, fitted with a means securing the lock to prevent accidental removal.

- The connection and disconnection with the MQC plate shall be easy, with adequate guidance alignment and orientation. Prevention of damage of the couplers when connecting and disconnecting shall prevail.
- The hydraulic couplers shall include check valves and be designed for multiple make and break operations. (If accidental disconnect, bleed off Master valve and SCSSV is mandatory)
- A high pressure protecting plate, ROV installable/retrievable shall be provided for all the MQC connectors when not used and parked in the tree when removed.
- Hydraulic couplers shall minimize water ingress considering surface P&T and mud line P&T.
- The MQC plate shall allow connection of the couplers under maximum pressure.

6.4.2 Umbilicals and jumpers

6.4.2.1 Work over umbilical and jumper

The work-over control umbilical and associated jumpers shall be designed to give access to the functions specified in the "MQC connectors and associated functions" paragraph, either directly or through the subsea control module. It shall provide the hydraulic and electric communication to perform these functions. These umbilical and jumpers shall be equipped with MQC plates.

The same workover umbilical (clamped along the drill string) shall be used for running and installing the tree and during drilling activities (clamped on the drilling riser). On one end, it shall be connected to the surface control unit by means of a jumper. To the other end it shall incorporate a quick connector for connection to the LMRP, in order to be able to disconnect both LMRP and umbilical in case of any need. This connector shall also fit for use for the tree installation and it shall provide emergency quick disconnection capabilities on the tree running tool (see tree running tool).

The clamps used for the fixation of the umbilical along the outside of the marine riser shall be analyzed, designed and qualified for actual design and operating conditions.

Electric and hydraulic flying lead(s) or jumpers should be necessary from the LMRP to the tree (jumpers shall be terminated by MQC plates for tree connection). Flying lead(s) may also be necessary from the tree running tool to the tree.

6.4.2.2 Tubing Hanger umbilical

The tubing hanger umbilical (run in the drilling riser with the landing string for tubing hanger and internal tree cap installation), shall be designed to give access to the tubing hanger and running tool functions. The hydraulic couplers and electrical connectors of this umbilical shall be directly linked to the riser control module on pigtails.

6.4.2.3 General characteristics

The umbilicals and jumpers shall be multi hose bundles consisting of individual hoses integrated in an outer protection sheath.

Fast operating time shall drive the design of the hoses.



For inside riser umbilicals, size and clamping shall minimize the risk of snagging and damage to the outer sheath. The clamps shall take the complete load. Their design shall minimize the installation time.

The umbilicals shall be designed for mechanical constraints and fatigue loads they will be submitted. The hose shall be compatible with the fluid it drives through and keep their properties in the temperature envelop they will remain. They shall be pressure rated to fit the requirement related to their function.

The rig specificities (air gap, rig layout, BOP stack, etc.) shall be taken into account to calculate the required length of the umbilicals. A safety margin shall also be integrated to compensate the losses of umbilical length for adjustments and connection during the whole life of the umbilical.

6.4.3 Umbilical winches

The umbilical winches shall be designed for safe and efficient handling of umbilicals from semi submersible or monohull vessels, and shall be capable of handling the complete fluid filled umbilical length plus a surplus length of 20%, in accordance with the following requirements:

- Each winch shall be designed to provide a constant umbilical tension during installation/make-up of the riser in order to avoid slack on the umbilical along the riser. The tension load shall be adjustable to cater for differences in routing and suspension of the umbilical (number and location of sheaves, etc.).
- The tension system shall provide dynamic response characteristics capable of handling sudden and unplanned movement of the riser without exceeding allowable tension of the umbilical.
- It shall be possible to lock the winch in any position, while in the tension mode.
- The winch shall be either pneumatically powered from the drilling vessel air supply, or hydraulically powered from the WOCS HPU.
- There shall be sufficient speed to operate the umbilical safely and efficiently in all running configurations (including wire and drill pipe) at all field water depths, and shall allow fast payout of the umbilical in an emergency situation.
- The winch shall be equipped with an automatic transverse reciprocating spooling system to ensure even distribution of the umbilical on the drum. The winch shall be capable of handling an umbilical reel in/reel out angle of 0-80°.
- An interlock shall prevent the winches from being operated while the jumpers are being connected.
- A rotary joint shall be included for lines which require constant hydraulic pressure during deployment of modules.
- The winch shall be equipped with an automatic disc brake system, designed to slip at a tension lower than the umbilical working load (including dynamic forces), but higher than the umbilical static weight load with the necessary safety margins.
- The tubing hanger umbilical winch shall be equipped with the control panel at the winch face, fed from the WOCS HPU through swivel connections for hydraulic supply and return.
- Overall weight and size shall be minimized without compromising safety and efficiency. Maximum weight acceptable is 40T with the umbilical filled up.



- Each winch shall be operated by a hand carried remote control unit in addition to local control on the reels. The start of the reeling motion shall be soft, to avoid impact loads on the umbilical.
- The skid shall be skid mounted with protection for transportation and handling.

6.4.4 Master control unit

The Master control unit shall be a unitized assembly providing the following functions:

- Low pressure and high pressure hydraulic power generation and regulation.
- Pressure accumulation to allow three complete subsea operations of all valves without being recharged by the unit pumps.
- Transmission and reception of the required electric signals to operate the full workover control system and associated shut down and emergency functions.
- Interface with all other sub-assemblies within the system: the workover control umbilical and the tubing hanger umbilical, rig chemical supply hoses, ESD panels, remote control panels, UPS, etc.
- Control panels for Christmas Tree (valve operation and connection to wellhead functions), tubing hanger, landing string & surface tree, alarm & shut down, hydraulic power unit + backup.

The master control unit shall receive its electric and pneumatic supply from the rig utilities and is interconnected to the other units of the control system by jumper hoses and jumper cables.

The master pumps shall be electrically operated. The stand-by pumps shall be pneumatically operated, for redundancy purposes.

Pumping capabilities requirements: The pump system shall be capable to pressurize the topside accumulators within 15 minutes, and to maintain the system pressure during all operational modes.

The master control unit shall have two reservoirs. The return reservoir shall have sufficient capacity above the high level switch to allow draining down the complete accumulator system.

The master control unit shall have facilities for fluid circulation and filtering. The hydraulic fluid cleanliness shall be NAS 6.

The Master control unit shall be totally enclosed, air pressured, mounted on a heavy duty skid, and prepared for being handled by crane and forklift. It is dedicated to be installed on the main deck of the rig (zone 2).

The unit shall be properly lightened, especially around panels and cable/umbilical termination points and designed for easy maintenance. All equipment shall comply with the safety zone requirement it is installed in.

For maintenance and repair, the unit shall be designed for an easy access to all components.

The control fluid shall be similar as the one specified for the production control system.

All elements exposed to external environment shall be protected against corrosion.



6.4.5 Master control unit panels for Christmas Tree and tubing hanger

The panels shall display the graphical mimics of the Christmas Tree / tools stack up and the tubing hanger/landing string/surface tree stack-up. Push buttons shall allow selecting and executing every function either in sequence or individually.

The panels shall be installed in the master control unit, but separated from the hydraulic power unit for noise protection.

The panels shall be explosion proof. The status of operated valves shall be evidenced on the panel with color coding.

A button shall be pushed on to energize the functions controlled by the panel.

Operation of the panels at night shall be possible (lights).

A key operated switch shall be provided for transfer of control from the master control unit panels to remote control panels. It shall not be possible to operate the main panels and the remote panels at the same time.

An ROV operation monitoring shall be provided.

Digital data recorder shall be provided.

A flowmeter shall give information on the fluid flowing in the umbilical when actuating any hydraulic function.

6.4.6 Master control unit alarm/shut down and emergency disconnect panel

This panel shall incorporate push buttons that allow to activate the sequences for shut downs and disconnections as described in the automatic shut down and disconnect functions paragraph.

This panel shall also provide clear identification of the alarm conditions.

The minimum alarms (visible and audible) that shall be identified shall be (but may not be limited to the following):

- High pressure low level
- Low pressure low level
- Loss of electric power supply
- Air supply low level
- UPS malfunction
- Hydraulic fluids reservoirs high and low levels

The ESD and emergency disconnect functions shall be able to be operated without key operated switch, but shall be protected against accidental operation.

In the event of electrical failure on the rig, back up battery shall be provided to ensure successful shut down or disconnection during one hour. Lighting shall be also maintained during the same time.

A manual reset switch shall be incorporated to the panel to restore operation of the system after a shut down.



6.4.7 Master control unit hydraulic power unit panel

This panel shall provide control and status monitoring of the main functions within the hydraulic power unit, including hydraulic, pneumatic and electric power supply and distribution systems.

6.4.8 Remote control panel

A remote control panel shall be provided to be used on the drill floor, preferably in the drill floor control room (sufficient electric cable length shall be provided). It shall be electrically connected to the Master control unit to provide all tree functions, tree connection functions, tubing hanger, landing string and surface tree functions. The remote control panel shall operate as a slave for the master control panel, activated by a switch on the master control panel.

- The remote control panel shall provide the same mimic as the Master control unit panels. Push buttons shall operate the functions.
- The remote control panel shall provide indication of all operated valves status, even when the control is switched to the Master control unit. Critical functions shall be protected by individual protective covers.
- The remote control panel shall be completely enclosed in a protective cover, and installed on the drill floor.

6.4.9 Remote ESD mini panels

Two ESD mini panels shall be provided, and shall be supplied with sufficient provision of electrical cable for direct connection to the Master control unit.

- Both mini panels shall incorporate two buttons for initiation of both ESD modes, and two buttons for initiation of both emergency disconnect modes.
- Push buttons with lights to verify the operation status shall be included. A protective cover shall prevent the buttons from accidental operation.

7. Test requirements

7.1 Introduction

All Units and Systems shall be tested in accordance with the outline requirements identified in **GS EP SPS 001**, the requirements described below and the relevant industry standards. This chapter outlines minimum requirements for the testing of the main subsea Christmas Tree Units and Systems.

The Manufacturer shall make sure to provide all the equipment required to perform the tests as described in this section.

7.2 Qualification

All the WOCS components and tooling not proven at Project water depth shall be qualified in accordance with industry recognized standards and Company specifications. Qualification and testing of all the components shall be associated with special procedures. Design, qualification programs, qualification results, testing programs and testing results shall be submitted to client approval.



7.3 Verification Test

The purpose of the Verification Test is to prove that the WOCS satisfy all the loads, pressure integrity, installation, retrieval and functional performances listed in the specification.

As a minimum, the WOCS system shall be interfaced with the Project type of tree. All ROV functionality's shall be tested.

A full WOCS Verification Test shall be performed. The WOCS Verification Test shall be performed with use of facilities with capability of verifying correct assembly, pressure integrity and correct functionality of the system. All associated tools shall be used to verify all internal interfaces.

The WOCS Verification test shall include stack-up and pressure test of the complete system using the appropriate running tools using the installation sequence and procedure used in the field.

7.4 Unit Factory Acceptance Test (FAT)

Factory acceptance test (FAT) of all Units shall prove that the components of a Unit and the Unit itself satisfy all specified requirements to strength and functional performance.

WOCS Assembly FAT: Pressure test, function and drift test of the complete system assembly and all associated caps on offshore test stump, or appropriate dummy template as required, using dummy HPU or shop facilities with direct connection to SCM mounting base hydraulic and electric connections.

7.5 HXT System FAT/Extended Factory Acceptance Test (EFAT)

A full system FAT/EFAT shall be performed.

The WOCS FAT shall be performed on a test stump with capability of verifying correct assembly, pressure integrity and correct functionality of the system. All associated tools shall be used to verify all interfaces within the System.

7.6 System Integration Testing

A System Integration Test shall be performed to prove the interfaces to the Tree System.

ROV and any specific tools manufactured to interface with the WOCS, other interfacing tools as appropriate.

Actual equipment shall be used to conduct the System Integration Test.

Test procedures shall replicate actual field conditions wherever possible.

Contingency and emergency tools shall also be demonstrated during this test.

7.7 Shallow Water test

A shallow water test shall be conducted with the same equipment as in paragraph, System Integration Test. The aim is to prove the installation in shallow water. The requirements are the same as for System Integration Test.