



Exploration & Production

GENERAL SPECIFICATION

SUBSEA SYSTEMS

GS SPS 014

Drill through horizontal tree systems
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1. Scope

This technical specification is applicable to the Drill Through Horizontal Xmas-Tree systems (DTHT) for subsea production and/or injection wells. It defines the technical requirements for the individual components and/or equipment Units of the DTHT System. These comprise of the permanently installed subsea production equipment and associated main running tools. The workover/completion systems required to install and commission the equipment and perform intervention work are described in **GS SPS 017**. The specification does not identify all components of a complete DTHT System. It is the CONTRACTORS responsibility to identify all Units which are part of his complete System.

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 SPS 001**, and shall be therefore read in conjunction with said document and other COMPANY specifications and standards identified therein. The relationship between the main COMPANY documents defining the requirements to the Subsea Stations is illustrated in **GS SPS 001**.

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

Standards

Applicable industry standards and specifications are defined in reference **GS SPS 001**. In addition, reference is made to the latest revision of the following codes and 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	Drilling and Production Equipment, Wellhead and Christmas Tree Equipment
ISO 898	Part I bolts, screws and nuts
NAS 1638	National Aerospace Standard for flushing and cleaning
NACE MR-01-75	Material Requirements. Sulphide Stress Cracking Resistant, Metallic Material for Oil Field Equipment
ASME	Boiler and Pressure Vessel Code

**Professional Documents**

Reference	Title
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 17D	Specification for Subsea Wellhead and Christmas Tree Equipment
API 5 CT	Specification for Casing and Tubing
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 SPS 001	Design Philosophy and Requirements for Subsea Stations
GS SPS 002	Design of Subsea Structures
GS SPS 003	Foundation design considerations for Subsea Stations
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 Stations
GS SPS 010	Preservation Requirements for Subsea Package

Reference	Title
GS SPS 011	Mechanical Completion for Subsea stations
GS SPS 012	Documentation Requirements for Subsea Stations
GS SPS 013	Wellhead and Guidance Systems
GS SPS 015	Subsea 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 for Drill Horizontal Tree
GS SPS 018	Light Intervention Systems for Drill Horizontal Tree
GS SPS 019	Subsea Production Control System
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

3. Introduction

3.1 Definitions

See **GS SPS 001**.

3.2 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, other relevant standards and statutory requirements. Any deviation from any of the requirements defined herein shall be clearly indicated and treated as a non-conformance.

3.3 Abbreviations

The following abbreviations are used in this specification:

AAV	Annulus Access Valve
AMV	Annulus Master Valve
AWV	Annulus Wing Valve
BOP	Blowout Preventer
CIV	Chemical Injection Valve
DTHT	Drill Through Horizontal Tree
ETHR	Emergency Tubing Hanger Recovery Tool
EQD	Emergency Quick Disconnect



EQDP	Emergency Quick Disconnect Package
ITC	Internal Tree Cap
JM	Jumper Module
LRP	Lower Riser Package
MIV	Methanol Injection Valve
MTHRT	Mechanical Tubing Hanger Running Tool
PCS	Production Control System
PCV	Production Choke Valve
PDF	Production Flow Diagram
PGB	Production Guide Base
PMV	Production Master Valve
PWV	Production Wing Valve
ROV	Remote Operated Vehicle
SCM	Subsea Control Module
SCSSV	Surface Controlled Sub Surface Safety Valve
SLV	Service Line Valve
SSTT	Sub Sea Test Tree
STT	Surface Test Tree
TCTV	Tree Cap Test Valve
TH	Tubing Hanger
THRT	Tubing Hanger Running Tool
TMGB	Template Mounted Guide Base
TRT	Tree Running Tool
WH	Wellhead
WOCS	Workover Control System
WST	Wellhead connector Seal Test

4. System description

4.1 System overview

The Subsea Xmas Tree System comprises of a set of equipment which can be divided into two groups:

- Permanently Installed Equipment
- Workover/Completion Equipment

This specification covers the following permanently installed main sub systems with running tools and auxiliary equipment:

- Tubing Hanger System
- Drill Through Horizontal Tree Assembly

The Wellhead System is covered by a separate specification **GS SPS 013**.

4.2 Drill Through Horizontal Tree (DTHT) system options

The DTHT systems shall be used on development projects which may vary in form and function, dependent on a number of factors determined by field conditions and development strategy. The DTHT 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 1 A - integrated template/manifold
 - Concept 1 B - modular template/manifold
- **Concept 2:** Individual Wells Connected to a Subsea Manifold Centre
 - Concept 2 A - cluster configuration
 - Concept 2 B - satellite configuration
- **Concept 3:** 2 slots structure (water or gas injection)
- **Concept 4:** Individual wells in daisy chain configuration (water or gas injection)

This specification is valid for all DTHT options required to form any configuration, with or without choke, DGB, etc. The various development concepts, pressure regimes and water depths may be covered by the same Units where this is feasible without compromising any of the requirements specified in this document and where a positive cost benefit can be demonstrated.

The DTHT will be used on light architecture wells and on heavy architecture wells. In the case of the heavy architecture wells the DTHT will be installed after the 10-3/4" casing string is run.

A proposed or indicative Production Flow Diagram is provided (see annex) for both Producer and Injector wells. The PFD for Producers is applicable for both producers and gas injectors. These are provided for information only and modifications can be implemented by the SUPPLIER, providing they are clearly indicated and submitted to the Project Group agreement.

5. Principal equipment (or product) requirements

5.1 Introduction

The following paragraphs define the principal equipment or product requirements for all units included within the Drill Through Horizontal Tree (DTHT) System. The general philosophies, functional, operational and technical requirements to the subsea station are defined in **GS SPS 001**.

5.2 Scope of the specification

This specification applies to the tubing hanger and Drill through Horizontal Tree Equipment and directly associated tooling. For the Drill through Horizontal Tree, the specification do not cover the connector at the end of the flowspool which interfaces with either the template connector, or



the jumper connector or the flow line connector. For this connection, reference is made to document **GS SPS 007**.

The Specification does not cover the Control pod. For this equipment, reference is made to the document **GS SPS 019**, Specification for Production control System.

5.3 General requirements

The DTHT System shall be designed to operate on the mudline under the specific field conditions and operating life. Requirements for control of the different valves in the DTHT system during the workover/completion and production phases are given in Appendix (see PDF attached).

The basic design pressure for the DTHT System is 5000 psi. However, some hydraulic functions require a 10K hydraulic pressure. The components of the units which can be in contact with such high pressures even in the event of a failure on the first sealing element shall be designed to withstand this pressure.

During drilling or other down hole operations adequate protection of the DTHT internals, such as seal areas and landing/locking profiles with the ITC and TH removed, shall be provided by means of bore protectors/wear bushings. The protectors shall avoid mechanical damage to all relevant profiles and seal areas, and shall prevent deposition of particles in the lateral outlets and corresponding valve cavities.

The DTHT system specified within this document is a comparatively new system within the industry and as such the following general specifications do incorporate several more technical or detailed requirements. The purpose of these more detailed requirements is to assist the CONTRACTOR in the further development of their system to cater for any unique aspect identified that require specific attention.

The principal Drill Through Design capability for the Tree is for 12-1/4" section drill through, with the subsea BOP connected to its top hub. Therefore the 10-3/4" casing hanger shall be also run through the tree.

The tree shall provide a pressure containing conduit for the produced or injected fluid. It links the wellhead to the jumper or subsea manifold. The Christmas tree shall provide the ability to control and isolate the well pressure.

The horizontal tree shall receive the production tubing hanger and incorporate the production, annulus, injection and control line isolation valves, as well as electrical access lines for tree and down-hole sensors. All valves shall be controlled from surface and/or ROV operated. See proposed PFD in appendix.

A production insert choke and a sub sea control module shall be installed on the tree. Both shall be ROV replaceable without the necessity to pull out the tree.

The communication to the electric and hydraulic functions in the hole shall be provided by lateral penetrations through the tree. The hydraulic penetrations shall be located above the production bore, the electric penetrations can be located either above or below the production bore. The stab couplers between the tree and the tubing hanger shall be either ROV operated or passive (automatic actuation when landing the tubing hanger).

Vertical flow isolation and access shall be achieved by a slick line retrievable plug in the tubing hanger and an internal tree cap. The internal tree cap shall also incorporate a slick line retrievable isolation plug. To be able to permanently benefit from the two sealing barriers this equipment is to be capable for providing the monitoring of the pressure in the cavity created by the tubing hanger and the internal tree cap.



The tree shall be run and retrieved on drill pipes from a drilling rig. The tree frame shall provide adequate guidance for guidelineless runs. It shall be designed to accommodate impact loads generated by handling and installation phases and close by well operations (see section 11.7 on the tree frame). The ability to install and to remove the DTHT from the wellhead while using the BOP and Drilling riser shall be evaluated within the design, even for the case that this is only for parking on another slot temporarily.

The tree shall provide a suitable interface between the well head and the BOP stack for drilling and workover purposes and between the wellhead and the intervention riser package for light intervention.

Batch drilling sequences and drill through capabilities increase the risk to have objects falling on a tree, from the drilling rig. Therefore the production and annulus master valves as well as the annulus access valve shall be integral to the tree body.

As a general requirement all sealing submitted to a well flow (production or injection) shall have as its primary sealing a metal to metal type seal.

All non metallic seals used in the DTHT System shall be compatible with the fluids in contact. This compatibility shall be either field proven or assessed by extended compatibility tests with the related fluid.

The drill through ability also implies the necessity for the electronic sensors on the tree and the control pods to be resistant to the shocks and vibrations induced by the drill string motion. All tree spools, piping and umbilicals shall be firmly attached to the tree frame for the same reasons. In addition the lower connector shall withstand the increased bending moments and fatigue loads exerted because of the higher position of the BOP (top of the tree).

All equipment shall be designed for safe and efficient handling and make up with the maximum operating conditions of the drilling rigs.

5.4 Drill through horizontal tree barrier and valve configuration

The subsea DTHT System shall be configured in accordance with the dual barrier element philosophy, which implies there shall be two independent testable barriers between the produced fluids and the environment. A barrier element, in this context, is defined as a gate valve, needle valve or bore plug with metal to metal seals.

Well flow and annulus pressure are controlled by gate valves in the lateral bores. As a minimum, the production and annulus master valves and annulus access valve shall be integral with the DTHT block.

Vertical flow isolation shall be achieved by use of a wireline installed plug in the Tubing Hanger (TH) and an Internal Tree Cap (ITC) installed in the tree block above the TH which provides sufficient spacing between them to overcome possible debris accumulation problems induced by the ITC run. The ITC shall incorporate another wireline retrievable isolation plug. For both plugs and the ITC, primary seals shall be metal to metal.

Both barrier elements shall have the facility to be tested bi-directionally. Additionally, a facility to test between the plugs from the work over and production control system shall be provided.

The design shall allow for communication from production to annulus. Communication shall be established downstream the production master valve and upstream the production wing valve.

All valves shall be capable of sealing with low pressure differentials and with marginal pressure gradients.

The location of the DTHT below the BOP induces the necessity for the tree to abide by a double barrier against any pressurised effluent between the well and the environment during all drilling, completion or work-over operation. This requirement adds itself to the double barrier philosophy always demanded for production phases and intervention operation. It has strong implications on many equipment specifications, such as the sealing ability of the tree bore protectors in front of the penetration, the use of an additional barrier (compared to the sole VX type gasket) on the tree lower connection, the doubling of the production and annulus tree valves. One will refer to the detailed specification on the related items of equipment.

5.5 Subsea chokes

For some applications, the tree assembly shall incorporate a retrievable choke on the flow loop between the wing valve and the flowline connector. Detailed requirements for the choke and associated running/retrieval tool are described in [GS SPS 016](#).

5.6 Production control system

Reference is made to [GS SPS 019](#).

5.7 Xmas-tree flowline/Umbilical tie-in

Reference is made to [GS SPS 007](#).

5.8 Wellhead systems

For requirements to the wellhead system, reference is made to [GS SPS 013](#).

6. Tubing Hanger system (TH)

6.1 General

This section defines the requirements of the main Units of the tubing hanger system for Drill Through Horizontal Trees. Dependent on CONTRACTORS detailed design, other Units or combined Units shall be added as required to achieve a complete system.

The following key aspects are to be included within the TH design:

1. The tubing hanger system shall run, install and suspend the production tubing string in the tree block and provide a pressure tight transition from the production string to the flow loop of the tree.
2. Installation and retrieval of the tubing hanger shall be performed by use of a hydraulically operated tubing hanger running tool on landing string and riser, or by a mechanical tubing hanger running tool on drill string.
3. The TH system shall be deployed inside the marine riser and BOP. All components of the system, including umbilical clamps and connectors shall be designed to minimize the risk of snagging and shall have sufficient strength to avoid deformation affecting the function of the component, or loss of components in the well, in the event of snagging.
4. The various TH tools with the TH or ITC attached shall be capable of passing through the BOP flex joint with the joint deflected to an angle of two degrees.
5. After installation of the tubing hanger, communication to hydraulic and electric functions in the well shall be achieved by operation of lateral stab couplers, penetrating through the

DTHT block. Extension and retraction of the stab couplers shall be performed by either hydraulic, ROV or automatic mechanical action.

6. Sealing of the couplers shall be achieved by metal to metal seals, located both below and above the penetration of the block. Special care shall be taken when designing for horizontal penetrators to avoid damage during set down of hanger.
7. The tubing hanger system shall be designed such that the possibility of collecting and trapping debris is minimized. The system shall include the necessary drill string deployed tools for cleaning of sensitive areas in the tree and the tubing hanger system, prior to landing of the various Units. The cleaning tool shall include magnetized junk basket and shall include a pin type drill pipe connection at the bottom.
8. The system shall further include all test/handling tools necessary for onshore and offshore testing and installation. The TH system shall include facilities to support the TH at working level on the drill floor and allow easy make-up of the THRT, without damaging the hydraulic and electric lines. A false rotary (slips) shall be included. The false rotary shall be designed allowing running of the TH on hydraulic THRT and landing string, with the umbilical clamped to the landing string.
9. The TH system shall have a minimum through bore exceeding the ID of completion string (7" tubing, #26, L80, 13% Cr - premium connections, i.e. minimum 6,276") or the OD of any equipment to be run through, unless otherwise required by project specific design basis.
10. Tension capacity and pressure rating of the various components of the TH system shall be project specific and homogeneous with the maximum pressure and tension expected during installation and operation.

6.2 Tubing Hanger (TH) assembly

The Tubing Hanger shall suspend the production tubing string in the tree block and provide a pressure tight transition from the production string to the flow loop of the tree by means of metal to metal seal arrangements.

The Tubing Hanger shall be designed with a maximum 18-3/4" OD and a minimum through bore exceeding the ID of completion string (7" tubing, #26, i.e. minimum 6,276"), in accordance with the following requirements:

API Classification	Producer and gas injector wells	Water Injector wells
PSL	3	3
API temperature classification	S or T	S or T
API retained fluid classification	FF	DD
Working pressure (psi)	Project specific	Project specific

1. It shall be run, oriented, landed, locked and tested in the DTHT in a single trip.
2. There shall be a sealing system utilizing a primary metal to metal seal above and below the production side outlet. The seal system shall be bi-directional.
3. TH shall be oriented prior to landing inside the DTHT.

4. The orientation system and the various components of the landing string shall be designed to tolerate the torque and the vertical load generated by rotation of the production string in a horizontal well during orientation.
5. The TH shall be fully oriented before the TH seals are energized inside the DTHT body.
6. It shall be possible to verify pressure integrity of each energized seal elements after installation of the TH. Test pressure shall be applied upstream the seal, in the direction of flow.
7. Sealing shall withstand hydro-static pressure with atmospheric pressure in the production bore.
8. The tubing hanger shall be machined with a landing nipple profile above the production side outlet to accept an isolation plug. The position of the profile shall be designed to give a dead space of at least one plug diameter above the tubing hanger side outlet.
9. The bottom connection of the TH shall be a premium connection, details to be verified from project specific design basis.
10. The TH shall have sufficient material for at least one thread re-cut without the need for weld inlay, in the event of damage to the threads. All threads shall be manufactured per MANUFACTURER instructions and supplied with protectors.
11. The Tubing Hanger shall be supplied with a pup joint made up to the torque required for the actual thread type and pressure tested in the plant. The pup joint shall be supplied complete with protectors. Length of the pup joint will be 1.5 m minimum. Type of thread will be project specific.
12. The TH lock down mechanism shall be designed to prevent movement of the TH resulting from any loads acting on it. If a self locking taper type of mechanism is used to lock the TH into the tree, a secondary mechanical locking arrangement shall be incorporated as back-up (spring loaded shear pins or similar).
13. The TH shall be supplied with a set of test plugs for pressure testing (on surface) of the TH with pup joint to maximum working pressure.
14. The application of and the associated equipment for soft landing shall be evaluated.
15. Seal surfaces associated with TH wireline plugs, pack off seal assemblies, all seal surfaces permanently installed subsea, including areas not permanently used and all areas in contact with the produced fluid shall be inlaid with corrosion resistant material.

6.3 Isolation plug

1. After installation of the TH, vertical access shall be blocked and pressure isolated above the production outlet, with use of a wireline retrievable plug incorporating a metal to metal sealing system with elastomeric back ups.
2. The metal to metal seal shall be designed to minimize the risk of galling during installation.
3. The bottom part of the plug shall be erosion resistant and protect the metal to metal seal.
4. Associated running and pulling tools shall be provided.

6.4 Penetrations

1. The TH shall be designed with capacity to provide hydraulic and electric communication for the following down-hole functions: (see PFD in appendix)

Penetrations requirements			Well Type	
Feature	Size	WP	Producer	Injector
SCSSV, HP hydraulic line	1/4"	10K	X	X
Chemical injection line	1/2"	5K	X	
Spear Chemical injection line	1/2"	5K	X	
Spare (LP) hydraulic line	1/4"	10K	X	X
Spare hydraulic line	1/4"	10K	X	X
Electric line	1/4"		X	X
Spare Electric line	1/4"		X	X

2. There shall be no check valves in the hydraulic lines at the TH level.
3. The hydraulic control line penetrator in the TH shall be self venting. Termination at the bottom of the TH shall be swage lock unless otherwise specified.
4. To reduce the number of leak paths, no cross-overs will be accepted and all connection points within in the penetrator assembly shall be welded.
5. Special care shall be taken when designing for the horizontal penetrators to avoid damage or ingress of contaminants during the set down and retrieval of the hanger.
6. The penetrations shall be designed to allow retrieval of the TH if the actuation mechanism fails to retract.
7. Sealing of the couplers shall be achieved with metal to metal seals. Secondary sealing located both below and above the penetration area is also to be metal to metal. Both primary and secondary seals are to be designed for the expected maximum pressure of the hydraulic system. This pressure will be established following the SUPPLIER and project group design pressure.
8. The connections of electric and hydraulic lines at the bottom of the TH shall be designed in such a way that damage while running the completion inside the drilling riser and BOP is avoided.
9. The horizontal stroking electrical connection interface shall be made up with pressure compensated type conductive electrical connectors. The female half of the horizontal stroking connector shall be installed in the TH.
10. Hydraulic control line material will be INCOLOY 825.

6.5 Isolation sleeve

1. The TH shall be supplied with an internal wireline runnable/retrievable isolation sleeve (or straddle), for isolation of the production outlet, to allow circulation of the production string during running/retrieval.
2. This sleeve is to be designed to withstand internal pressure in the event of a kick while running the completion.
3. The TH isolation sleeve design shall be optimised to maximise the ID according to the maximum wellhead shut in pressure expected.

4. It shall be possible to run the TH with pre-installed isolation/Protection sleeve.

6.6 Protection sleeve

1. During Down Hole operations, adequate protection of the ITC and TH internals, such as seal areas and landing/locking profiles, shall be provided by means of wireline deployed bore protectors. These shall allow free passage of subsequent wireline tool strings with smooth transitions to the bore. The TH system shall be supplied with one bore protector for the TH plug profiles, and one capable of protecting the plug profiles of both the TH and ITC with the plugs removed for Down Hole operations. The bore protectors shall be suspended and locked in the TH and/or the ITC.
2. Seal surfaces associated with TH wireline plugs, pack off seal assemblies, all seal surfaces permanently installed subsea, including areas not permanently used and all areas in contact with the produced or injected fluid shall be inlaid with corrosion resistant material.

6.7 Dual protection sleeve (optional)

In order to save operations rig time, following equipment and associated WL running/retrieving tool shall be proposed:

One bore protector capable of protecting the plug profiles of both the TH and ITC with the plugs removed for Down Hole operations. The bore protectors shall be suspended and locked in the ITC.

7. Hydraulically operated Tubing Hanger Running Tool (THRT) system

The following design requirements shall apply:

1. The THRT shall be used to run and retrieve the TH and the ITC.
2. The THRT shall latch onto the TH and provide pressure tight seals for the production bore. Sealing shall be effective with external hydrostatic pressure (brine) and atmospheric pressure inside.
3. The THRT shall provide full bore access to the production bore, designed to allow downhole wireline and coiled tubing work and installation of TH and ITC wireline plug and associated isolation/protection sleeve.
4. The THRT/TH latch function shall be maintained in latched position by active hydraulic pressure during deployment of the running string. However, the latch mechanism shall be designed such that it is unaffected by loss of hydraulic pressure (i.e. a dedicated hydraulic unlatch function is necessary).
5. The THRT with the landing string shall have a contingency mechanical release function allowing separation from the TH if hydraulic control is lost.
6. All interface connections in the TH system, i.e. TH/THRT, THRT/SSTT, shall be stab mandrels and control line stabs with non metallic seals and minimize water ingress.
7. The TH system shall be designed to withstand the external pressure caused by pressure testing to maximum working pressure via the BOP choke/kill line, with the annular bag or a pipe ram closed around the appropriate part of the system.

8. A protective cap shall be provided for the lower end of the THRT. The cap shall be designed to allow racking of the THRT/Lower Landing String Assembly and riser joint/joints in the derrick.
9. The THRT shall be designed for re-entry into a locked tubing hanger, to facilitate workover or retrieval as required.
10. It shall be possible to establish distance between the wellhead and the rig rotary for riser space-out purposes, by means of a physical contact between the TH system and the BOP, during installation of the TH and re-entry for retrieval.
11. The THRT shall incorporate a function to verify correct lock down of the TH in the tree.
12. The THRT shall be designed to resist the combined load of maximum rated riser tension, production and annulus bore pressures and any tensile loads generated by THRT setting pressure. It shall also withstand the bending moments applied by a 3° riser angle.
13. The THRT shall be supplied with a test stump to allow pressure testing the bore of the THRT without requiring a TH.

8. Mechanical THRT (MTHRT)

The availability of a Mechanical Tubing Hanger Retrieving Tool (MTHRT), making it possible to retrieve the TH and ITC on drill pipe or completion landing string, is to be made in accordance with the following design requirements:

1. The MTHRT shall latch mechanically into the lock down mechanism and seal against the bore of the TH or ITC.
2. It shall remain sealed to the main bore after unlocking of the TH or ITC to allow circulation down the production string.
3. It shall provide a minimum through bore allowing installation or retrieval of the crown plugs and related protection or straddle sleeve.
4. It shall be capable of unlocking the TH or ITC using either direct pull or hydraulic pressure through the drill string or BOP choke and kill lines. No additional hydraulic control line are permissible.
5. The upper connection shall be designed to allow the connection of either the completion landing string joints or drill pipes.
6. The tool shall be equipped with a secondary release feature to allow emergency release from the TH or ITC.
7. The tool shall be designed to minimize the dragging and snagging inside the marine drilling riser during running/retrieval.
8. It shall be designed with a mechanical strength homogeneous with the completion landing string.

9. Emergency Tubing Hanger Recovery Tool (ETHRT)

The TH system shall include an Emergency THRT (ETHRT) with mechanical strength exceeding the MTHRT, capable of retrieving the Tubing Hanger mechanically by use of drill pipe. There shall be no requirement to use the WOCS. The following design requirements shall apply:

1. The ETHRT shall latch onto the TH and provide pressure tight seals for the production bore.
2. It shall remain sealed to the bore after unlocking of the TH.
3. It shall be possible to circulate down the production bore during recovery of the Tubing Hanger.
4. It shall include a drill pipe connection. Drill pipe connection specifications to be specified later.
5. It shall be designed with a mechanical strength in accordance with the project specific drill string pull force.

10. Tubing hanger associated equipment

10.1 Tubing hanger test stand

The TH test stand shall meet the following requirements:

1. The test stand shall support the TH in vertical position with the production pup joint made up.
2. It shall allow make-up of the THRT to the TH in both work shop and offshore conditions.
3. It shall provide access to all hydraulic and electrical functions and TH test caps for connection of test lines and cables.
4. It shall allow complete function testing of the TH system with the THRT latched onto the TH and accommodate pressure testing of the TH with pup joint and all hydraulic lines.
5. There shall be access for general cleaning and inspection of the TH assembly and easy replacement of the TH seals.
6. Lifting from horizontal to vertical position shall be possible with use of the supplied sling.
7. The test stand shall provide a stability to tolerate 10 degrees tilt offshore, with a safety margin of 1.3, with the THRT attached.

10.2 Tubing hanger handling tool (offshore tool)

The offshore TH handling tool shall be mechanically operated, in compliance with the following design requirements:

1. The tool shall include a drill pipe pup joint to facilitate handling of the tool with drill pipe elevator. The pup joint length is to be 18", type of drill pipe thread is project specific and will be specified later based upon the project design basis.
2. The tool shall include a 3" diameter flow path through the center of the tool to facilitate pumping through the tool into the tubing.
3. The tool shall lock into the TH while the TH is in the canister and shall allow installation of the TH to the tubing string.



4. It shall be possible to use the handling tool with a plug or isolation/protection sleeve pre-installed in the TH.
5. The tool shall include a locking feature to avoid accidental unlatching.
6. The tool shall be rated for an internal pressure based upon the project specific working pressures and shall be capable of lifting the TH including the entire tubing string. The tool shall be manufactured to **API 17D**, PLS 2.

10.3 Universal tubing hanger handling tool

The TH system shall include a tool for lifting/handling of the TH and ITC designed to the following requirements:

1. The tool shall be capable of handling the TH during assembly, testing and maintenance in workshop conditions and offshore.
2. It shall be capable of being attached to the top of the TH by hand within the inner bore.
3. It shall have the capacity of being used to lift the TH from horizontal to vertical position by a single lift wire.
4. It shall be designed with the objective of avoiding accidental unlatching during lifting.

10.4 Tubing hanger transportation box

The TH transportation box shall be fabricated from steel and provide adequate protection of the TH **including pre-installed pup joint** during onshore and offshore handling and transportation, and shall comply with the following requirements:

1. The transportation box shall be designed for long-term storage of the TH.
2. It shall allow inspection of the TH seals with the transportation box in upright position, and shall allow drifting of TH internal bores without removing the TH from the box.
3. It shall allow connection of the THRT to the TH inside the transportation box, with the box in upright position.
4. It shall be designed with the objective of ensuring safe handling of the TH in offshore conditions, on drill floor or vessel deck, without the need for climbing onto the unit.
5. It shall be possible to lift the box from horizontal to vertical position by using the slings.
6. It shall tolerate a tilt of 30° in horizontal position and 10° in upright position with a design stability safety factor of 1.3.
7. Any loose items such as covers etc. shall be secured to the structure with chains.
8. The main opening for access to the TH shall include a hinged cover with a mechanical arrangement to lock the cover in open position.

10.5 THRT transportation box/basket

The system shall include transportation boxes/baskets for all TH running tools. The THRT transportation Units shall provide adequate protection for safe transportation of the THRT with lower end of the landing string, including protection/test caps, and shall be designed in accordance with the requirements described for the TH transportation box.

11. Drill through horizontal tree assembly and associated tools and equipment

The Drill Through Horizontal Xmas Tree (DTHT) Assembly includes the following main sub assemblies:

- Drill Through Horizontal X-Mas Tree Assembly
- Drill Through Horizontal X-Mas Tree Running Tool
- Internal Tree Cap
- Debris Cap
- Bore Protectors
- Auxiliary Equipment.

Dependent on CONTRACTORS detailed design, other Units or combined Units shall be added as required to achieve a complete system. This section defines the requirements to the DTHT.

11.1 Material requirement

All surfaces in contact with the produced or injected fluids shall be inlayed to meet following requirement:

	Producer and gas injector wells	Water Injector wells
PSL	3	3
API temperature classification	S or T	S or T
API retained fluid classification	FF	DD
Working pressure (psi)	Project specific	Project specific

All sealing area shall be hard faced (inconel inlayed) as API specification.

11.2 Corrosion and cathodic protection

With respect corrosion the requirements for the DTHT are documented in [GS SPS 009](#) documents.

All bolted on components shall have grounding straps to ensure continuity with the cathodic protection system.

11.3 Drill through horizontal tree assembly

Type: Horizontal, Drill through, 5"1/8 x 2"1/16, 5000 psi. WP

11.3.1 General

The Drill Through Horizontal Tree (DTHT) comprises of the valve block with wellhead connector, re-entry mandrel, control pod mounting base and guide structure.



The following design requirements shall apply:

1. The DTHT shall be designed for through-bore drilling with a 12-1/4" bit.
2. The DTHT shall be designed for being able to run and install a 10-3/4" casing hanger in the wellhead.
3. The DTHT system shall incorporate an accurate guidance system for landing of the BOP stack.
4. The option of either installing the DTHT with the control module connected or without is to be included within the design. Detailed analysis to the application of either option is to be provided.
5. All connector performance specification are to be verified by riser analysis. All parameters used within the riser analysis are to be provided by the project design basis.
6. Control of the necessary functions on the DTHT shall be achieved by a jumper umbilical from the TRT or the BOP with an ROV operated multibore stab.
7. It shall be possible to override and lock open all X-Mas Tree valves by using ROV.
8. The DTHT design shall incorporate diverless methods and tool packages for replacement of the choke valve and the control pod, with the debris cap in place.
9. All hydraulic piping and fittings intentionally left unpainted shall be connected to the cathodic protection system.
10. All side outlets in the tree spool shall be designed with the objective of avoiding debris settlement.
11. An access to the cavity between the internal tree cap and the tubing hanger shall be provided. The access shall incorporate an ROV operated isolation valve, flanged to the treehead (TCTV), and a pressure sensor. Three functions will be assigned to this port:
 - Flow-by area when setting the internal tree cap.
 - Test port to control the sealing ability of the internal tree cap and its isolation plugs.
 - Pressure monitoring of the cavity during production.
12. The top of the tree head should be designed with sufficient spacing between the top of the tubing hanger and the internal tree cap, in order to overcome debris accumulation problems induced by the internal tree cap run.
13. The DTHT shall be designed to allow integration of a retrievable choke valve, located downstream the production wing valve.
14. The DTHT system shall be designed to allow continuous injection of methanol or scale inhibitor or similar into the production bore, as required. The injection line shall incorporate a dual barrier against the produced fluid. The injection line shall include an orifice valve to provide a means of adjusting the injection flow rate.
15. The DTHT weight and dimensions shall not exceed the current rig capabilities.

Tree Maximum weight: 40T. Christmas Tree carrier: inside dimensions: 5.5 m wide * 5.5 m long * 3.5 m deep.
16. The DTHT, once completely assembled shall be gas tested following PSL 3 API requirements.

11.3.2 Valve block

1. The valve block shall provide the required sealing areas and landing/locking profiles to home the tubing hanger and internal tree cap and insure the required functions at the required rates. If specific tests are required for the tubing hanger (see related paragraph), the treehead shall provide the facilities to carry them out.
2. The Upper hub shall be integral to the tree. Provide an external locking profile compatible with BOP stack (18"3/4 SHD H4 Vetco connector equipped with 27" inserts). The connector profile shall be similar to the wellhead high pressure housing top connector as they interfere with same BOP connector. The connector shall withstand the clamping force from a heavy duty BOP connector without any distortion. The BOP stack is of the funnel down type. A back up sealing area shall be provided.
3. Lower connector. The hub of the lower connector shall be integral to the tree. The lower connector shall be interfaced with the wellhead high pressure housing top profile (compatible with the BOP connector, 18"3/4 Super Heavy Duty H4 Vetco equipped with 27" inserts). The tree shall be able to be connected not only on future development wells, but also on all already installed wellheads (exploration and appraisal wells). See lower connector paragraph.
4. There shall be one 5"ID master production / injection valve integral with the block in the production bore (see GS SPS 015).
5. There shall be one 2"1/16 ID annulus master and one 2"1/16 ID annulus access valve integral with the block in the annulus bores (see GS SPS 015).
6. A dedicated flanged connection for the production/injection wing block, sizes of which are project specific and are to be provided within the project design basis.
7. A dedicated flanged connection for the annulus wing block, sizes of which are project specific and are to be provided within the project design basis.
8. An access to the annulus for heavy workover operation or circulation with the tubing hanger installed (eg with a subsea BOP and a drilling riser, using the kill and choke lines), shall be provided, either above or below the internal tree cap.

11.4 Lower tree connector

1. The DTHT Lower connector is to be capable of being connected to an H4 18"3/4 x 27" mandrel external profile with a VX/HX internal sealing profile. The connector hub shall be integral with the tree body. It is to be operable from either the TRT or a BOP. The SUPPLIER shall make sure that it will fit the wellheads already in place on the exploration and appraisal wells. The isolation sleeve, run with the tree should also adapt and fulfil the requirements.
2. **Remarks:** the well heads in place at the moment use Vetco 18"3/4 H4 HP housing external profile, and are internally fitted with ABB MS700 18"3/4 system or FMC UWD 15 18"3/4 system.
3. Sealing shall be provided by a VX type gasket. A VX type gasket release mechanism shall be provided for any change out requirements. Change out of the VX type gasket shall be possible with ROV.
4. The bending capacity of the connector shall be high enough to withstand the bending moments induced by the riser/BOP-LMRP as well as the shear stresses on the connector. The connector shall also withstand the tensile strength exerted during the drilling operations

by the riser tensioners. The SUPPLIER shall perform an analysis to determine the maximum value of the bending moments in the operating conditions.

5. The primary locking mechanism shall be mechanically or hydraulically operated. If an hydraulic connector is proposed, a secondary unlatch hydraulically operated and a mechanical secondary unlocking mechanism, ROV operated, shall be provided. (ROV mechanical override).
6. A visual indication by ROV should insure that the connector is locked.
7. The tree connector shall be designed such that it should be impossible to disconnect by an unplanned operation.
8. The hydraulic locking mechanism shall withstand the vibrations originated by drilling activities.
9. A test port fitted with ROV operated valve shall provide the ability to test the connector sealing. See also the specification on the isolation sleeve. The valve should be flanged directly on the tree head with a pressure rating corresponding to the rating of the connector. The test shall be carried out through the work over control umbilical (see related paragraph).
10. The connector shall be designed to prevent hydrates formation into the connector.

11.5 Isolation sleeve

The isolation sleeve isolates the wellhead to tree connection. In order to fulfil the double barrier philosophy required for drilling operations, the seal created with the VX type gasket shall be backed up by a secondary pressure containment means using the isolation sleeve. The following design requirements shall apply:

1. The isolation sleeve shall provide pressure sealing above the VX type gasket (in the tree) and below (in the wellhead). It shall be a permanent equipment.
2. It shall be run with the tree and set when landing the tree. The above required sealing shall be obtained as soon as the tree is landed.
3. The pressure rating shall be the same as the tree connector.
4. A port shall provide an hydraulic access to the cavity existing between the VX type gasket and the isolation sleeve for gasket test purposes (see paragraph "tree head or valve block" or "Lower tree connector" paragraph) and pressure monitoring during the internal test of the isolation sleeve.
5. The DTHT is required to be connected to pre-drilled exploration wells and as such the isolation sleeve is to be able to be installed on a standard wellhead while still fulfilling the double barrier philosophy on the connector side. As such the sleeve could be different for different wells. If this is the case a clear identifiable distinction for the different sleeves is required.

11.6 Penetrations

Producer wells and gas injectors: 7 penetrations will be laterally fitted through the valve block for communication of the electric and hydraulic functions. The breakdown is as follows:

- 5 hydraulic penetrations. The penetration lines are as follows:
 - 1 SCSSV control line, 1/4", 10000 psi



- 2 Chemical lines, ½", 5000 psi for scale inhibitor and corrosion inhibitor on one line, for back up and/or methanol injection on the other line
- 2 spare hydraulic lines ¼", 10000 psi for possible future intelligent completion tools
- 2 electric penetrations (downhole P & T monitoring and spare line). The stab couplers to the tubing hanger will be actuated according to the SUPPLIER's best design.

Water injector wells: 5 penetrations will be laterally fitted through the valve block for communication of the electric and hydraulic functions. The breakdown is as follows:

- 3 hydraulic penetrations following with the same features as above:
 - 1 SCSSV control line, ¼", 10000 psi
 - 2 spare hydraulic lines ¼", 10000 psi for possible future intelligent completion tools
 - 2 electric penetrations (downhole P & T monitoring and spare line). Same features as above for the producer wells
 - All penetrations through the DTHT, such as control lines for SCSSV and downhole chemical injection lines, shall be equipped with ROV operated isolation valves flanged to the treehead, (see valves and actuators paragraph).
1. The hydraulic penetrations shall be positioned above the production bore.
 2. The hydraulic stab couplers to the tubing hanger will be actuated either by ROV intervention or automatically when landing the tubing hanger.
 3. Detailed information on the design of the electrical stab connectors shall be provided.
 4. The penetrations shall be reliable for retraction.
 5. A contingency solution to retract the penetrations will be proposed. Shearing off in case of failure to retract is not satisfactory. The solution shall be evaluated and documented.
 6. All Hydraulic penetrations through the DTHT, such as control lines for SSSV and downhole chemical injection lines, shall be equipped with ROV operated isolation valves flanged to the treehead, (see valves and actuators paragraph).
 7. See also the specifications for the penetrations in the tubing hanger part.

11.7 Tree sensors

Pressure and/or temperature sensors shall be fitted to the tree at the following levels:

- P & T upstream choke (between the production master valve and the production wing valve).
- P & T downstream choke.
- P & T on the annulus bore (between the annulus master valve and the annulus wing valve).
- Pressure only of the cavity between the internal tree cap and the tubing hanger (a test port shall be available to incorporate the sensor).

Remark: The production and annulus sensors may be fitted to the wing valve blocks.

1. All sensors shall have a back up.
2. A sand production detector shall be installed downstream the choke for producer wells. This sand detector shall be ROV replaceable.

3. Additionally the sensors shall withstand the vibrations and shocks induced by the drilling activities through the tree.

11.8 DTHT tree frame

The tree frame shall support the tree system and auxiliary components.

1. The DTHT frame work shall be designed in such a manner that the DTHT can be handled and stored on a flat base, with the TRT connected, without being latched to a designated test or transportation stump, with the lower connector and isolation sleeve in place.
2. The tree frame shall provide guidelineless features for running and installation of the treehead on the wellhead. The lower guidance system shall be funnel down.
3. An orientation system shall be provided when landing the tree on the production guide base or the template. This orientation system shall be accurate enough to fulfil a proper alignment for the connection of the flow line. This orientation will be documented, including the orientation tolerances.
4. The guidance and orientation system shall provide for proper alignment prior to engage the isolation sleeve seals.
5. The tree frame in its upper part shall provide a guidance system for the BOP landing. The tree provider shall set contact with the drilling CONTRACTOR, when elected, to adapt both BOP (if required) and tree frame for an effective system. The BOP stack is equipped funnel down.
6. The tree frame shall provide protection of the DTHT during surface handling and subsea running or retrieving operation.
7. Critical components mounted on the tree (actuator, wing valves, pod, rods, choke, etc.) shall be protected by the tree frame against falling objects from surface (see Design Philosophy and Requirements for Subsea Stations).
8. The tree frame shall provide structural mounting for:
 - Tree head and wing block.
 - Subsea control module. The mounting system shall allow retrieval and rerun of the subsea control module from surface, without pulling the tree. Efficient guidance is then necessary.
 - Choke. The mounting system, with ROV assistance, shall allow retrieval and rerun of the insert choke from surface, without pulling the tree. Efficient guidance is then necessary.
 - ROV panel and override systems.
 - Control system connection plates.
 - Flowspools and piping.
 - Connector to the production flow base or template production base, towards the manifold.
 - Cabling (flying leads) and connections.
 - Anodes.

Remark: The whole tree frame and tree system shall be properly weight balanced for handling and running purposes.



Remark: All the piping and fittings on the tree frame shall be connected to the cathodic protection system.

9. The tree frame shall be designed to allow the ROV to carry out visual observation for inspection and visual check of actuators and choke position.
10. Whatever the base structure (production guide base or template), the tree frame ROV panel and the connection plates for the control system shall be easily accessible. All gas injection and production trees on one side and water injection trees on the other side should be interchangeable.
11. The tree frame shall incorporate the required number of docking points for the ROV to operate during all the phases of installation, production and workover operations.
12. The interface of the tree frame with the rig (skidding beams, moonpool beams, hanging facilities through the moonpool, etc.) shall be designed in accordance with the rigs that will be used. The trees shall be handled with the existing drilling rig facilities.
13. Overall dimensions for the tree ready to be run on the well shall fit with the rig Christmas Tree carrier: inside dimens. 5.5 m wide * 5.5 m long * 3.5 m deep. Tree Maximum weight: 40T.
14. The ROV panel shall be located on only one side of the tree.

11.8.1 Production/injection wing blocks (see indicative PFD)

A production/injection wing block shall be flanged to the valve block (5000 psi pressure rating). Its main objective is to provide the tree with a secondary production/injection path closing facility, namely the production/injection wing valve (see attached proposed PFD). The following design requirements shall apply:

1. One 5"1/8 5000 psi production/injection wing valve.
2. One 5"1/8 5000 psi flanged connection for the production/injection flowline (connection to the choke valve body).
3. One 2"1/16 5000 psi flanged connection for the crossover line (communication of the production/injection flowline with the annulus service line). A 2"1/16 x 5000 psi access shall be provided in the production/injection wing block to connect a cross over line from this connection up to the annulus wing block. The cross over line shall intercept the production/injection bore upstream the production/injection wing valve and downstream the production master valve. On Production and Gas Injection Trees, this cross over line shall be connected to the methanol injection line (see PFD attached).
4. One 5000 psi flanged connection and access port to the production/injection flowline to fit a pressure and temperature sensor. As specified in the DTH Tree description part, this item could be directly incorporated to the block.
5. For the Production and Gas Injection trees, the wing block shall be internally clad with inconel.

11.9 Annulus wing block

An annulus wing block shall be flanged to the treehead (5000 psi pressure rating). Its main objective is to provide the tree with a secondary annulus service path closing facility, namely the annulus wing valves. The following design requirements shall apply:

1. One 2"1/16 5000 psi annulus wing valve.



2. One 2"1/16 5000 psi flanged connection for the annulus cross over line line.
3. One 5000 psi flanged connection and access port to the annulus line to fit a pressure and temperature sensor, for monitoring purposes, upstream the annulus master valve (injection direction). As specified in the DTH Tree description part, this could be directly incorporated to the Tree.

11.10 Flowspools

The production/injection flowspool incorporates the pipe from the choke to the flowline connector which connects to the interface with the jumper or the subsea manifold (production guide base or template).

On all wells, a cross-over line shall allow the communication between the annulus and production bore.

For Production and Gas Injection wells, the annulus flowspool incorporates the annulus service line spool from the annulus wing block to the flowline connector.

The following design requirements shall apply:

1. The production/injection flowspool pipe should be a 5"1/8 x 5000 psi rigid pipe with minimum bends and maximum bending radius, flanged or welded to the choke at one end and linked to the connector at the other end according to the SUPPLIER specification.
2. The annulus service line spool should be a 2"1/16 x 5000 psi rigid pipe with minimum bends and maximum bending radius, flanged to the annulus wing block at one end and linked to the connector at the other end.
3. The flowspools design shall minimize vibrations, and be compatible with ingressing fluids and erosion risks.
4. The flowspools rigidity shall cope with the connection tolerances. It shall be properly documented.
5. All the sealings in the flowspools shall be metal to metal.
6. It is the SUPPLIER's choice to determine whether the flowline connector should be horizontal or vertical (5000 psi pressure rated), unless specified in other operator's document. The design shall lead to an easy setting and releasing process, without damage to components or sealing elements. All trees, be they connected to a production guide base or a template, shall have the same design for this connector.
7. The connector shall incorporate a locking mechanism, hydraulically or mechanically operated. Unlock risks due to vibrations shall be overcome by an adapted design of the connector.
8. Downstream the choke, a sand detector shall be provided on the producer wells.
9. The cross over line shall be a 2"1/16 x 5000 psi rigid pipe.
10. For production trees, a 2"1/16 x 5000 psi valve, named service Line Valve (SLV), shall be inserted in the annulus service line for isolation.

Please refer to the PFD.

11.11 DTHT wear bushing (or bore protector)

The tree wear bushing shall provide the following main functions:

- a) Protection of the tree sealing areas and landing/locking profiles (for the tubing hanger and the internal tree cap) against the harmful effect of mechanical wears when drilling.
- b) Protection of the bores and valves present in the tree internal bore (penetrations, master production valve, master annulus valve, annulus wing valve) against the ingress or accumulation of debris in cavities. Suitable seals should be used to fulfil this requirement.
- c) Secondary sealing for the penetrations. This is to provide a double barrier with regards to the penetrations. The wear bushing shall provide pressure containing sealings upward and downward the penetrations area. The pressure rating shall be 5000 psi.
- d) The SUPPLIER shall insure the ability to change the sealings in case the wear bushing is pulled out and rerun, whatever the reason.

Additionally the following design requirements shall apply:

1. The wear bushing shall mechanically withstand, without permanent deformation, the internal pressure that may come from the well (tree pressure rating), with an external pressure corresponding to the sea water hydrostatic height.
2. It shall be installed in the tree on surface, and provide an automatic lock down mechanism, as well as an anti-rotation feature.
3. Although it is designed to remain in the tree until the well is ready for completion, it shall be retrievable once the tree is on the mud line at any time, and be reinstalled and locked down, tree on mud line. This could be performed several times during the drilling operation for status control. The design shall take this into consideration. The running tool shall be mechanically operated.
4. It shall be drifted to the external diameter of the 10"3/4 casing hanger (see wellhead specification). The wellhead wear bushings shall also be run and retrieved through the tree with the tree wear bushing installed.

11.12 Tubing hanger orientation mechanism

See additional data in the earlier TH section. The following design requirements shall apply:

1. The tubing hanger orientation should be tubing hanger or tree dependant only. No BOP fittings should be required to orient the tubing hanger.
2. The orientation system should remain as simple as possible.
3. It shall be fully operational when setting the tubing hanger, despite the torque generated by the completion string in the longest horizontal wells drilled. It shall also withstand the lateral and vertical loads.
4. The full orientation of the tubing hanger should be achieved prior to locking it and energising the tubing hanger seals.
5. In case a dedicated orientation sleeve is used, it should be orientated and locked in place. A test (eg: pickup test) should evidence the locking status.

11.13 Internal tree cap

The Internal Tree Cap (ITC) shall provide a secondary barrier element to the TH plug and shall be run after installation of the tubing hanger and subsequent installation of the wireline set TH

isolation plug. The ITC is landed, sealed off and latched above the tubing hanger inside the DTHT. It provides the second barrier between the well and the environment. The following design requirements shall apply:

1. The ITC shall provide a concentric vertical access to the well bore. The access is plugged by a wire line retrievable isolation plug.
2. This access bore shall allow the tubing hanger isolation plug to be retrieved with the internal tree cap in place.
3. The internal tree cap shall hold the pressure on both direction, externally when mating with the tree, and internally when mating with the isolation plug. BOP tests will be carried out against the ITC (in case of a major work over).
4. It shall be pressure rated for 10000 psi (homogeneous with hydraulic lines pressure rating)
5. Seal areas associated with ITC wireline plug, pack off seal assemblies, all seal surfaces permanently installed subsea, including areas not permanently used and all areas in contact with the produced fluid shall be inlaid with corrosion resistant material.
6. Externally, the type of sealing is the responsibility of the SUPPLIER; primary and secondary sealing is required. Internally, see "internal tree cap isolation plug" chapter.
7. The Internal tree cap shall be landed and locked in place in the tree.
8. The ITC locking mechanism shall be designed to prevent unlocking by vibrations.
9. The design shall be based on running and retrieval through the BOP and marine riser system.
10. The ITC shall be run and retrieved using the THRT and MTHRT (see related paragraphs here above).
11. There shall be a method of determining that the ITC is properly landed and locked to the tree.
12. The internal tree cap shall be able to be run with or without the isolation plug. Without the isolation plug, circulating while running the internal tree cap shall be possible.
13. The internal tree cap and/or valve block shall be able to allow to test the cavity between the tubing hanger and the internal tree cap. Moreover, periodic testing will be carried for barrier status control during the production. The design shall take this into consideration.

11.14 Internal tree cap isolation plug

A vertical access through the internal tree cap is necessary. This access shall be fitted with a wire line retrievable plug incorporating a metal to metal sealing system with elastomeric back up.

The following design requirements shall apply:

1. The isolation plug shall be pressure rated for 10000 psi, according to the hydraulic lines pressure.
2. The metal to metal sealing shall minimize the risk of galling during installation.
3. A protection sleeve shall be designed to fit in the internal tree cap when the crown plug is not in place, in order to protect the sealing and locking profiles against wire line damages. The sleeve shall be run and retrieved by wire line operation.

4. Associated wire-line running and pulling tool shall be provided.
5. The location of the plug in the tree cap shall be such that the top of the installed plug cannot be damaged upon installation of the running/retrieving tools.

11.15 Hydraulic piping and fittings

All hydraulic system components shall be adequately designed to minimise damage, stress and vibration during testing, handling, installation/retrieval and normal operations.

The routing of all hydraulic piping shall be carefully planned to minimise the possibility of damage. Wherever possible, piping shall be clamped or run in a tray. Tubing runs to the hydraulic tree connector shall be accessible such that they can be disconnected, vented or cut in order to release locked in fluid and allow mechanical override.

Continuous lengths of piping shall be used when possible.

Fittings assembly torque is to be independently verifies an sealed/secured to identify fittings that have been properly inspected. All threaded fittings shall be wire locked using 0.0035" diameter INCONEL 625 (or Project Group approved equivalent) wire to prevent vibration back out.

Fittings: "Swagelock" compression fittings shall be acceptable, however piping shall be run using the minimum number of fittings. Anti vibration fittings shall be used.

Due to line vibration caused by the stepping choke function, the choke control lines shall be welded connections with no compression fittings permitted. The line shall be firmly attached.

MeOH piping shall be welded with no fittings permitted. This shall also include all lines which may contain methanol. All welds shall be full penetration.

12. Internal tree cap running tools

The internal tree cap shall be run and retrieved with the same tools used for the tubing hanger (See tubing hanger running tool paragraphs).

The Emergency tubing hanger recovery tool should be suitable for the internal tree cap.

A dedicated wash tool shall be designed and supplied to clean the top of the tubing hanger. If the top profiles are different, a dedicated wash tool shall be provided for the ITC.

13. Drill through horizontal Tree Running Tool (TRT)

The DTHT shall be installed by use of a Tree Running Tool (TRT) with the following functional criteria:

1. The tree shall be run on drill pipes.
2. The TRT shall be hydraulically operated.
3. The TRT shall have a primary and a secondary release function. The primary release function shall be hydraulic. The secondary release function shall be mechanical. An hydraulic secondary release which is independent from the primary release function is also acceptable.
4. The top connection of the tree running tool to the drill pipes shall be easy to handle and make up, whether an adapter is required or not. See the drilling rig specification chapter to design the connection adapter for a user friendly use (handling connection, racking with DP stands, making up, etc.).

5. The tree running tool shall insure an interface between the work over control umbilical and the hydraulic and electric jumpers/flying lead to be connected to the tree.
6. The tree running tool shall incorporate a panel with a parking receptacle to carry the work over control umbilical or jumper while retrieving the tree running tool once the tree is installed or running it for tree retrieval.
7. Docking points shall be provided to suit all possible ROV operations.
8. The tree running tool shall be able to operate with or without the tree wear bushing in place.
9. The tree running tool shall have an air vent device for use in the splash zone to purge air from within the tree body.
10. A handling tool shall be designed for the tree running tool, for the surface handling of the tree. It shall be adapted to offshore handling requirements (transfer for supply boat to rig, etc.).
11. With the work-over control umbilical connected on the tree (on whatever MQC connector) quick disconnection of the tree running tool shall be performed within 60 seconds.

14. DTHT handling tool

A handling tool for lifting the complete DTHT assembly including SCM, Choke, bore protector and the DTHT test/transport skid is required. The tool shall be designed for lifting from supply boat to rig with a single point lifting wire. The handling tool shall be connected to the external profile of the DTHT re-entry hub. The handling tool shall be possible to use both with and without the DTHT bore protector installed in the DTHT.

15. Debris cap

A debris cap is run to prevent debris from falling into the tree and for corrosion protection inside the 18-3/4" Xmas tree re-entry hub. The following design requirements shall apply:

1. The same Debris cap shall be capable of being used on the Tree spool (with or without Internal Tree Cap fitted) and the 18"3/4 Wellhead housing.
2. The debris cap shall allow injection of corrosion inhibitor to protect the seal surface contained within the ITC/Tree spool or 18"3/4 Wellhead housing. The debris cap shall include necessary facilities for injection of the inhibitor at the right elevations inside the ITC/re-entry hub/wellhead housing, independent of the specific gravity of the inhibitor fluid relative to seawater. The corrosion injection shall be via an ROV installed hose from surface.
3. The Debris cap shall contain a locking mechanism to secure it to the H4 profile. It shall be equipped with a lift eye compatible with an ROV shackle.
4. The debris cap shall be run and retrieved by use of ROV.
5. In case of failure of the ROV retrieval operation, the debris cap shall be retrievable using drill pipes.
6. It shall not be pressure containing.

16. Production control system

The SUPPLIER shall refer to **GS SPS 019** this document for a full understanding of requirements and interfaces.

A control pod mounting base shall provide the interface between the control pod and the electric and hydraulic piping connected to the tree functions. Electrical functions may communicate with the control pod through the mounting base or may be directly connected to the control pod via electrical flying leads.

When planning the location of the control pod and mounting base, the following shall be considered:

Access for ROV to perform functions or observation on the control module. There shall be no restriction to tree mounted functions which require ROV intervention or observation.

The location shall facilitate retrieval/installation of the control pod, in line with the intervention philosophy.

The control pod shall be protected from damage during tree handling and transportation, installation and retrieval, drilling and production operations.

17. ROV panel

A single panel should be provided on the tree for the ROV actuation of valves, according to the following:

- The ROV panel shall give access to the ROV override functions for all the remote operated valves and the choke.
- The ROV panel shall also give access to all ROV operated valves.

All torque transfer mechanisms shall be designed for long term exposure to a subsea environment and shall not add significantly to the operating torque.

The panel shall include the valve and plates marking designation and shall include parking receptacles for ROV hot stabs, dummy plugs and caps, flying leads, etc. The marking system shall remain legible for the design life of the horizontal tree. Marking shall consider the potential for marine growth. Underwater visibility shall be considered in the choice of marking colour and finish.

ROV grab handles shall be included to assist in ROV operations.

18. Tree insulation

The tree body, production and annulus wing blocks and flowloops shall be designed to provide sufficient thermal insulation.

The insulation shall meet the design life and operating conditions.

19. Surface test equipment (test stump)

CONTRACTOR shall identify and include all auxiliary and test equipment required to perform handling, transportation, pre-operational checks/tests, and any special components required to install, test and operate the Units described in this specification.

In particular, the tree surface test stand shall include mandrel profile, capable of testing the tree to its maximum WP; in order to be able to land, lock and test the tree. It shall simulate the components mating parts and provide facilities for pressure testing. The test stand shall be suitable for rig testing all the tree system functions, and for carrying out all pressure tests on pressure containing tree equipment (gate valves, isolation valves, hydraulic circuits, penetrations, bore protectors, etc.).

20. Transportation skids

The transportation skids shall be designed for offshore transportation of the following assemblies:

- Christmas tree (as described in the « Christmas tree system paragraph »)
- Tree running tool
- Tubing hanger and running tool (optional; if so a dedicated transportation box, as specified in related paragraph, will home these equipment and fit in the tree transportation skid).

The skids shall provide protection of components against handling damage, and ease of handling for components and assemblies. Their design shall provide lifting points for offshore transportation.

21. Major workover specific tools

21.1 BOP test tool

In the even of a major workover, after installation of the drilling BOP and riser a test tool shall be run to perform BOP pressure test. The test tool shall:

1. Use the ITC running tool profile for connection
2. Provide sealing at ITC running profile
3. Provide a top connection allowing the use of a dedicated sub (dummy slick joint) to pressure test the BOP lower pipe rams
4. Be rated to the required working pressure.

21.2 Dummy slick joint

The dummy slick joint shall provide:

- A slick section for isolation of the annulus with BOP lower rams, a lower connection to the BOP test tool, and a upper connection to the drill string
- A correct space out to locate the drill string in front of the next BOP rams
- Be rated to the required working pressure
- Details for length, type of drill string connection to be agreed with project people later on.

21.3 Emergency isolation sleeve

An emergency isolation (or straddle) sleeve shall be designed for the case when the sealing area of the straddle sleeve inside the tubing hanger gets damaged.



It is to meet the following requirements:

- Isolate the TH side outlet, to be able to circulate down the production string or contain a well kick while pulling the TH and completion
- Lower sealing can be inside the first tubing below the TH
- It can use the same locking profile and upper sealing than the standard isolation sleeve
- ID shall permit circulation through it, 3" minimum
- Be rated to the required working pressure.

22. Test requirements

22.1 Introduction

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

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

22.2 Qualification

All the DTHT components and tooling not proven for the field water depth shall be qualified in accordance with industry recognised 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.

22.3 Verification test

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

As a minimum, the DTHT system will be interfaced with all type of Wellhead housing: light and heavy architecture and the potentially already installed wellhead housings. All ROV functionality's shall be tested.

A full DTHT system Verification Test shall be performed on a specified number of Tree covered by this specification. The DTHT system 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. Running tools assembled with Tree or tubing hanger shall be pressure tested.

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

The DTHT, once completely assembled shall be gas tested following PSL 3 API requirements.

22.4 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.

DTHT Assembly FAT: Pressure test, function and drift test of the complete tree 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.

22.5 DTHT System FAT/Extended Factory Acceptance Test (EFAT)

A full system FAT / EFAT shall be performed on a specified number of DTHT Systems covered by this specification. The EFAT for a DTHT system shall comprise the following type of tests:

- Drill Through Horizontal Tree System Test
- System Mechanical Tolerance Test.

The DTHT System FAT shall be performed on a test stump with capability of verifying correct assembly, pressure integrity and correct functionality of the DTHT System, comprising the tubing hanger system, the tree assembly with PGB, and the workover system. All associated tools shall be used to verify all interfaces within the System. After delivery of the running tools and associated control systems to COMPANY, dummy tools and control systems shall be used to complete these tests.

22.6 X-Mas tree system mechanical tolerance verification test

This test shall prove that the DTHT can be landed and connected to the wellhead (currently installed wellheads included) and PGB/Manifold and will hold pressure as specified, with the flowline mandrel in a position relative to the X-Mas Tree flowline connector, representing the worst possible offset locations in the vertical and horizontal planes, as well as rotation in all three planes. The PGB/Manifold mandrel shall not be restrained in this position.

The test conditions shall be defined from the stack-up tolerance study for the DTHT, wellhead and PGB or Manifold. The test shall be repeated for two additional arbitrary offset and rotational positions of the flowline mandrels at COMPANY's discretion. The final test shall contain a 1 hour gas test in the extreme offset position, followed by a back seal test to verify pressure integrity.

22.7 System integration testing

A System Integration Test shall be performed on the first system manufactures to prove the following interfaces to the DTHT System:

- Wellhead System (included wellheads previously installed on delineation wells)
- Completion System and WOCS
- Manifold or Jumper connection System
- Production Control System including control pod
- ROV
- Any specific tools manufactured to interface with the DTHT System
- Other interfacing tools as appropriate.

Actual equipment shall be used to conduct the System Integration Test. Permission from the Project Group is required prior to using replicas or fixtures in place of the actual equipment due to logistic or schedule problems.

Test procedures shall replicate actual field conditions wherever possible.

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

22.8 Shallow water test

A shallow water test shall be conducted with the same equipment listed in paragraph 11.9, System Integration Test. The aim is to prove the installation in shallow water. The requirements are the same as for System Integration Test.

22.9 Offshore test before installation

All the valves and equipment of the tree will be function and pressure tested on the drilling rig prior to running.

22.10 Offshore test at installation

The tree will be installed on the drilling wellhead housing using drill pipes and a dedicated running tool and umbilical. On the same trip (before installation of the BOP's) all the tree valves and equipment shall be function tested and all the valves (production, annulus, penetration) shall be pressure tested.

The lower connector VX type gasket shall be pressure tested against the isolation sleeve via the umbilical. The isolation sleeve shall be pressure tested from inside, monitoring the cavity via the umbilical.

Penetration ports shall be pressure tested against the bore protector via the umbilical.

The bore protector shall be pressure tested monitoring the cavity via the umbilical and one of the penetration lines.

All the production and annulus side outlet valves shall be pressure tested individually.

22.11 Drilling operations test

The tree shall be tested at the same time as the BOP.

As a minimum, a body test shall be performed, monitoring the pressure behind the isolation sleeve at the lower connector level (via the umbilical) and behind the tree bore protector (via the umbilical and one of the hydraulic penetration line).

A pressure test shall be performed via the umbilical for the lower connector VX type gasket against the isolation sleeve.

A pressure test should be also possible for the penetration ports against the bore protector.

22.12 Test prior to run the completion and clean-up

With the DTHT, the completion string is landed inside the tree. Special care must be taken to ensure that the tree is in perfect condition before running the completion in the well to limit as far as possible the risk of lost time due to pulling of the tree because of tree function failure.

In this way a full function and pressure test similar to the tests to be performed at installation is mandatory (except for the bore protector).

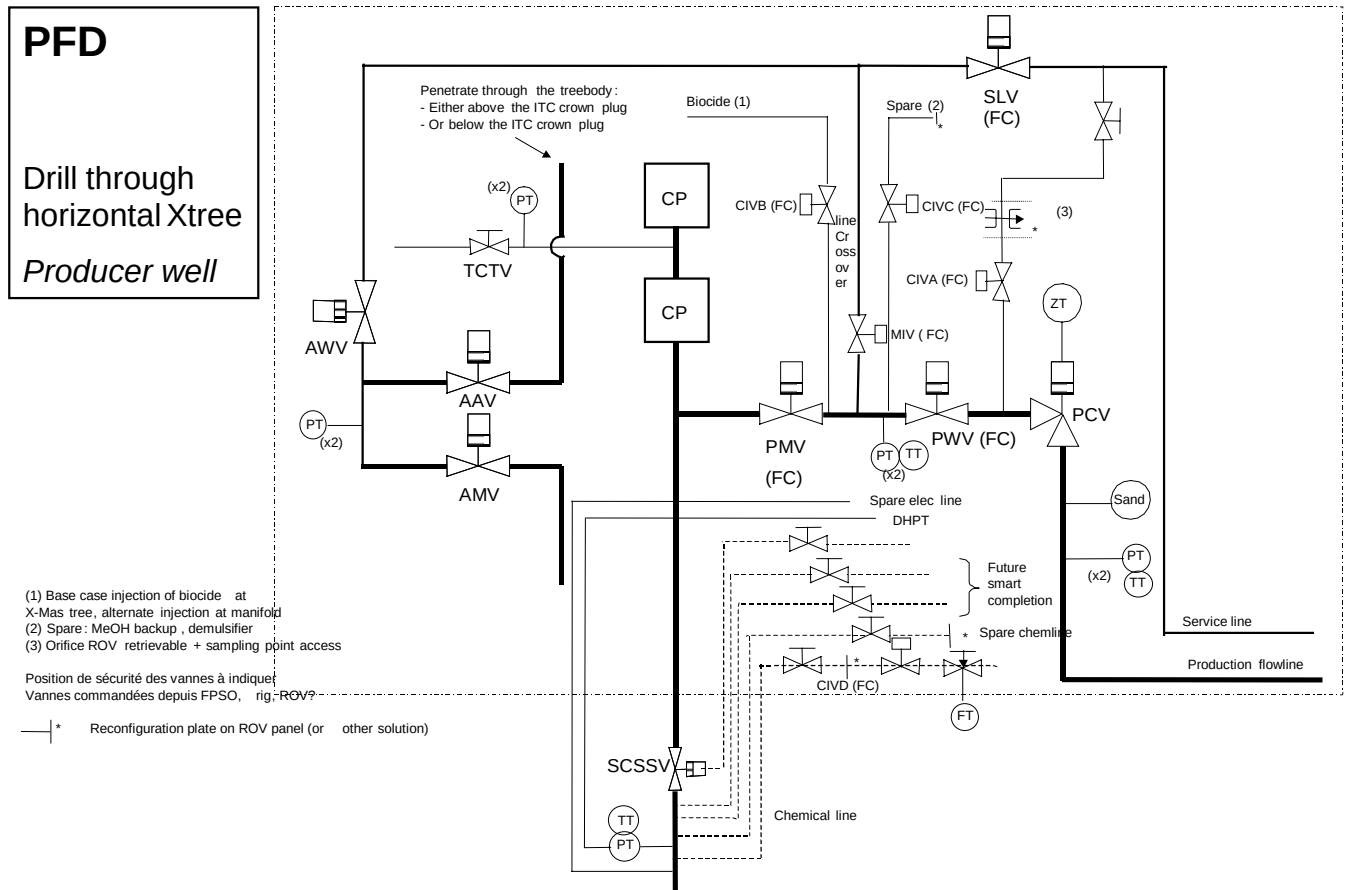


23. Test prior to run the completion and clean-up

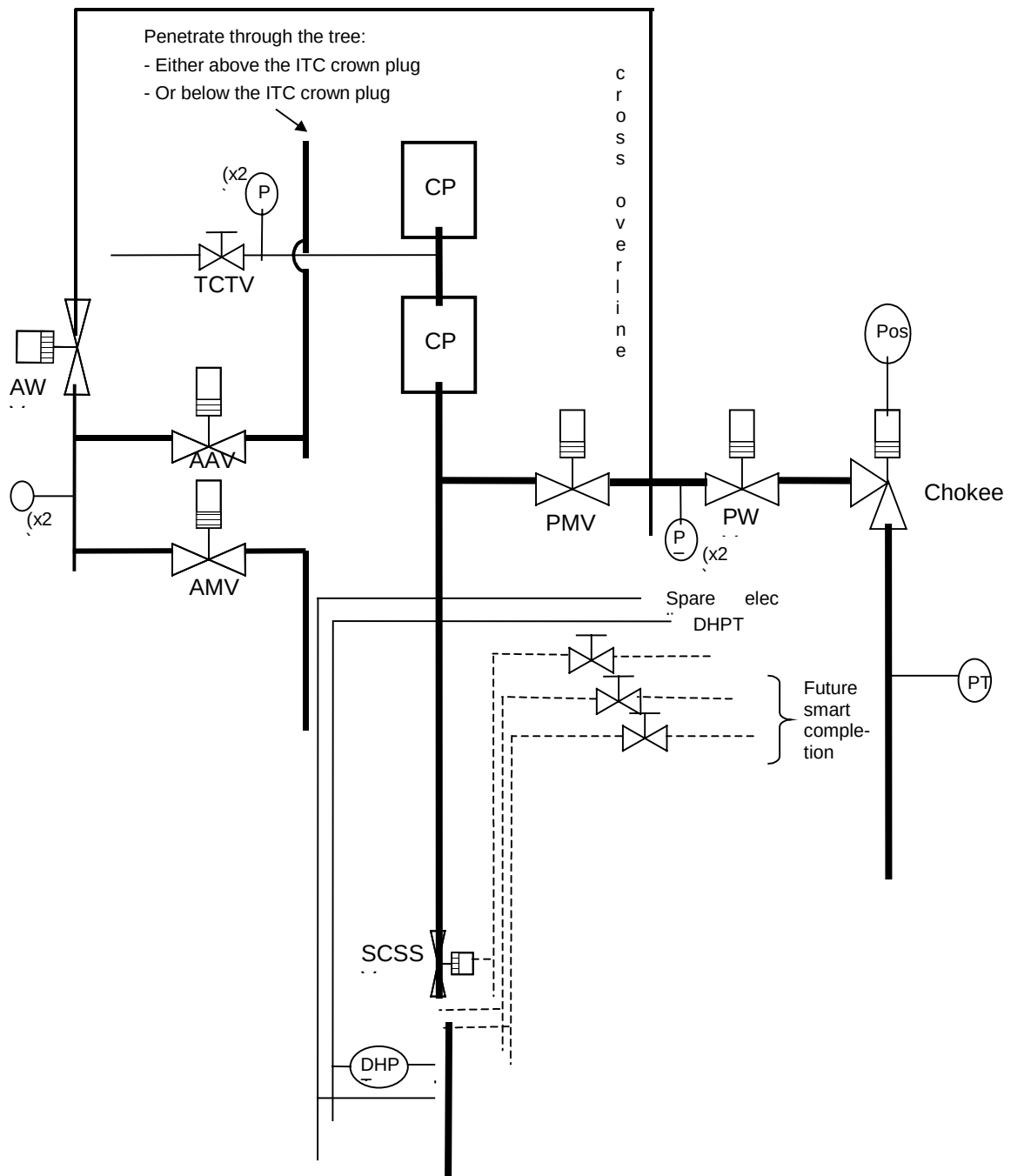
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Appendix 1 Drill through horizontal tree - Indicative PFD for production tree



Appendix 2 Drill through horizontal tree - Indicative PID for injection tree



Appendix 3 Valve configuration and operation modes for the DTHT

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