

GENERAL SPECIFICATION

Drilling & Wells

GS EP FP 414

Completion / Work Over (C/WO) System for Subsea Vertical Christmas Tree on Rental
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1. Scope

This specification is applicable to Completion & Work Over systems (C/WO) on rental basis for all the subsea wells equipped with a Subsea Vertical Christmas tree.

It defines the functional requirements for C/WO equipment required to perform Tubing Hanger and Christmas Tree installation, as well as the interventions and work over of these subsea wells during the life of field.

Various running tools, such as Tree Running Tool and Tubing Hanger Running Tools which are referenced here, are described within the respective tree system specifications ([GS EP FP 413](#)).

This specification does not identify all components of a complete C/WO system. It is the Contractor's responsibility to ensure that all the required equipment to fulfill all modes of operations is included. It is the Contractor's responsibility to identify and include any Units, and any auxiliary and test equipment required to perform handling, transportation, pre-operational checks / tests, and any special components required to install, test and operate the Completion & Workover system described in this specification, or Units that are specific to their C/WO system.

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

2. Reference documents

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

External Documents

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

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Reference	Title
API SPEC 6A	Specification for Wellhead and Christmas Tree Equipment
API RP 17H	Remotely Operated Vehicle Interfaces on Subsea Production Systems
DNV 2.7-1	Offshore containers
EN 12079 (Parts 1; 2; 3)	Offshore Containers and Associated Lifting Sets - Part 1: Offshore containers- design, manufacture and marking - Part 2: Lifting sets - Design, manufacture and marking - Part 3: Periodic inspection, examination and testing
IEC 60332	Tests on electric and optical fibre cables under fire conditions
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
IEC 61511	Functional safety - Safety instrumented systems for the process industry sector
ISO 10423	Petroleum and natural gas industries — Drilling and production equipment — Wellhead and Christmas tree equipment
ISO 13628-5	Petroleum and Natural Gas Industries - Design and operation of subsea production systems. Part 5: Subsea umbilicals
ISO 13628-6	Petroleum and natural gas industries - Design and operation of subsea production systems - Part 6 : subsea production control systems
ISO 13628-7	Petroleum and Natural Gas Industries - Design and operation of subsea production systems. Part 7: Completion/work over riser systems
ISO 13628-8	Petroleum and Natural Gas Industries - Design and operation of subsea production systems. Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems
ISO/TR 12489	Petroleum, petrochemical and natural gas industries -- Reliability modelling and calculation of safety systems
OLF 070	Application of IEC 61508 and IEC 61511 in The Norwegian Petroleum
SAE AS4059	Aerospace Fluid Power – Cleanliness Classification for Hydraulic Fluids

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Reference	Title
GS EP COR 356	Corrosion Protection of Fasteners
GS EP PJC 703	Requirements for Contractor Final Documentation
GS EP FP 413	Subsea vertical Dual Bore Christmas Tree
GS EP SPS 001	Subsea Production Systems General Design Requirements
GS EP SPS 004	Subsea Valves
GS EP SPS 006	Service Valves in Subsea Stations
GS EP SPS 009	Corrosion Protection of Subsea Stations
GS EP SPS 012	Documentation requirements for subsea stations
GS EP SPS 019	Subsea production control system
GS EP SPS 023	Cleaning and Flushing of Hydraulic Systems
GS EP SPS 025	Subsea Valve Actuators
GS EP SPS 029	Metallic Materials for Subsea Production Facilities
GS EP SPS 033	Subsea Intervention Tooling

3. Abbreviations

The following abbreviations are used in the document:

AAV	Annulus Access Valve
AIV	Annulus Isolation Valve
ASJ	Annular Slick Joint
ASV	Annulus Swab Valve
BOP	Blowout Preventer
CP	Cathodic Protection
CTLF	Coiled Tubing Lift Frame
C/WO	Completion & Work Over System
DSA	Diverter Spool Assembly
EDP	Emergency Disconnect Package
EFAT	Extended Factory Acceptance Test

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EFL	Electrical Flying Lead
EQD	Emergency Quick Disconnect
ESD	Emergency Shut Down
FAI	Fail As Is
FAT	Factory Acceptance Test
FMECA	Failure Mode Effects & Criticality Analysis
FSC	Fail Safe Close
HCR	High Collapse Resistant
HFL	Hydraulic Flying Lead
HMI	Human Machine Interface
HPU	Hydraulic Power Unit
ID	Internal Diameter
IRLS	In Riser Landing String
IWOCS	Installation & Work Over Control System
LP	Low Pressure
LPV	Lower Production Valve
LRP	Lower Riser Package
LWI	Light Well Intervention
MCS	Master Control station
MCU	Master Control Unit
MIV	Methanol Injection Valve
MODU	Mobile Offshore Drilling Unit
MQC	Multi Quick Connector
NDE	Non Destructive Examination
P&T	Pressure & Temperature
PCs	Portable Computer
PCS	Production Control System
PDF	Probability of Failure on Demand
POOH	Pull Out Of Hole
PSD	Production Shut Down
PSV	Production Swab Valve
PWV	Production Wing Valve
RAO	Response Amplitude Operator

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RACV	Riser Annulus Circulation Valve
RCM	Riser Control Module
RIH	Run In Hole
ROV	Remote Operated Vehicle
SCM	Subsea Control Module
SCMMB	Subsea Control Module Mounting Base
SCSSV	Surface Controlled Sub-Surface Safety Valve
SFT	Surface Flow tree
SLS	Simplified Landing String
SLV	Service Line Valve
SOM	Subsea Power Output Module
SPMV	Production Master Valve
SPWV	Surface Production Wing Valve
SSTT	SubSea Test Tree
SSTTLS	Sub Sea Test Tree Landing String
TH	Tubing Hanger
THEOCT	Tubing Hanger Elevation & Orientation Check Tool
THOJ	Tubing hanger Orientation Joint
THRT	Tubing Hanger Running Tool
UPS	Uninterrupted Power Supply
UPV	Upper Production Valve
WH	Wellhead
WCM	Workover Control Module
WCMMB	Workover Control Module Mounting Base
WOR	Work Over Riser
XOV	Cross Over Valve
XT	Christmas Tree
XTAC	Christmas Tree Adaptor Connector
XTCS	Christmas Tree Control System

4. System description

The Completion / Work Over (C/WO) system comprises of all equipment and associated control systems required to install and retrieve the various units of the Tubing Hanger (made up to the

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completion tubing) and Vertical Subsea Christmas Tree systems as well as to perform interventions & work over on these subsea wells.

4.1 Mode of Operations

The C/WO system will be configured to cover the following main modes of operation:

- Tubing Hanger Mode (or In Riser Landing String):
 - Completion installation (TH + completion string) and well flowing using the Sub Sea Test Tree Landing String (SSTLS) before first oil,
 - Completion installation (TH + completion string) using the Simplified Landing String (SLS) after first oil,
 - Work over on the wells during the field life using a MODU with marine riser & BOP,
 - Interference Tests to monitor downhole gauges data in a well that has been completed but the Xmas Tree not yet installed,
- Christmas Tree Mode (or Open Water Intervention String):
 - Installation and commissioning or retrieval of the Subsea Christmas on cable,
 - Installation or retrieval of the Subsea Christmas tree and well flowing using the work over riser and LRP/EDP system,
 - Well Intervention (i.e. well re-entry to perform operations such as wireline, electric logging, coiled tubing operations, stimulation / pumping, etc) during the field life using a MODU or Light Well Intervention vessel,

The C/WO system covered by this General Specification shall comprise of the main items in the following table (table 1), used either in "Tubing Hanger / In Riser Landing String mode" or in "Christmas Tree / Open Water Intervention String mode". This list is not exhaustive. The C/WO system shall include all necessary equipment and functionality to allow Contractors proposed system to safely and efficiently perform the operations.

Item	Tubing hanger mode In Riser Landing String	Christmas Tree mode Open Water Intervention String	Classified "Pressure Containing Well control" Ref section 4.5
LRP (inc Tree Running Tool, ref GS EP FP 413)		X	X
EDP		X	X
WCM		X	
Tubing Hanger running tool (ref GS EP FP 413)	X		

Item	Tubing hanger mode In Riser Landing String	Christmas Tree mode Open Water Intervention String	Classified "Pressure Containing Well control" Ref section 4.5
Simplified Landing String: Tubing Hanger Orientation Joint & Shear Joint & Annular Slick Joint	X		
Sub Sea Test Tree Assembly: Ported Slick Joint, Tubing Hanger Orientation Joint, Sub Sea Test Tree inc Latch, Shear Joint, Retainer Valve, Annular Slick Joint	X		X
Tubing Hanger orientation pin	X		X (part of BOP once installed)
Riser Control Module (if required)	X		
Adaptor joint	X		
Lower stress joints		X	X
Riser joints (work over riser)	X	X	X (XT mode or with SSTT in TH mode)
Lubricator valve	X	X	X (XT mode or with SSTT in TH mode)
Tension joint (optional)		X	X
Slick (cased wear) joint	X	X	X (XT mode or with SSTT in TH mode)
Surface Flow tree – inc Swivel	X	X	X (XT mode or with SSTT in TH mode)
Surface Circulation head – inc Swivel	X		
Tension frame	X	X	
Annulus access joint / sub	X	X	X (XT mode or with SSTT in TH mode)
IWOCS cabin	X	X	

Item	Tubing hanger mode In Riser Landing String	Christmas Tree mode Open Water Intervention String	Classified "Pressure Containing Well control" Ref section 4.5
Umbilical(s) and jumpers (incl sheaves & clamps)	X	X	
Remote panels and ancillary equipment	X	X	
Spider, hand slips, handling and make up tools (where applicable)	X	X	
Xovers / saver subs / side entry subs	X	X	
Test and transportation equipment	X	X	

Table 1: C/WO System main items

4.2 Operational Requirements

The following is a summary of the operational methodology which is envisaged for the drilling and completion campaign, which impacts on the selection and configuration of the C/WO equipment:

1. The preferred method of well clean up is via the Sub Sea Test Tree Landing String in Tubing Hanger Mode before first oil and via the installed Xmas Tree to the host production facility after first oil,
2. Where no live well operations are considered (existing field C/WO system, lack of production facilities), the installation of the Tubing Hanger and completion is deployed with a Simplified Landing String (SLS). Hydrocarbons are not be taken back to the rig through the SLS. The SLS does not include a subsea test tree, quick disconnect latch, a retainer valve or a surface flow tree (the later has to be replaced by a light weight circulation head),
3. The In Riser Landing String SSTLS is operated by a control system which ensures as a minimum that the SSTT emergency shear/close and unlatch functions are conducted in direct hydraulic functions, whether achieved by direct hydraulic, electro hydraulic or other means. The In Riser Landing String SSTLS may be used for live well operations during installation of the completion, or for live well operations as part of a work over,
4. The In Riser Landing String SLS should be operated by direct hydraulic controls. Emergency dis-connection of the MODU from the well is facilitated by shearing of the SLS's Shear Sub with the BOP Blind Shear Rams. However, should the CONTRACTOR's hydraulic analysis show that a direct hydraulic system is not suitable for the operations, then a Remote Control Module (RCM) may be offered,
5. The Open Water Intervention String is controlled by an electro-hydraulic multiplexed control system, and is intended to be used for all live well intervention operations,
6. The base case of C/WO systems – for In Riser & Open Water modes – is to utilise rental systems for new projects.

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4.3 Overall Requirements

The following general functional and design requirements shall be applied to the entire Completion / Work Over system or the relevant parts of it:

- The stack-up height, footprint and weight of the major packages is kept as compact and low as feasible to increase rig selection. This especially applies to the LRP, EDP, SFT and CTLF and all equipment to be racked back in the derrick:
 - A detailed weight control matrix is supplied at tender, and used as a live document during detailed engineering. Special reference is made to the XT/LRP/EDP stack,
 - 9.5m height limit on Skid/XT/LRP/EDP stack-up including lifting clearance for make-up and skidding into the moonpool,
 - 9 metric tons maximum assembled unit weight for the Landing String sections (SSTTLS or SLS) to be racked in the derrick,
 - The target maximum weight for any C/WO item, for a lift from supply vessel to the MODU is 40 metric tons.
- All components of the C/WO System are analysed, designed, and qualified for the most severe operating conditions. Required calculation data are provided by the Service Company. Calculation modes are indicated by the Contractor,
- The C/WO system provides a pressure containing conduit for wellbore, completion & testing fluids and the passage of the necessary well bore tools and equipment between the Tubing Hanger / Christmas Tree and the MODU,
- The C/WO system is designed to allow unhindered passage of all components required to perform well intervention including wire-line and coiled tubing tool strings and to establish the necessary well barriers from the MODU to the well,
- The In Riser Landing String C/WO components are designed with bevelled profiles for snag free running inside a marine drilling riser with the umbilical(s) attached to it,
- With the exception of work over controls umbilicals, all equipment is designed to withstand external hydrostatic pressure with atmospheric pressure inside. The external pressure may exceed seawater hydrostatic head due to specific gravities of drilling/completion fluids (In Riser Landing String mode only),
- The equipment may be run in completion brines and/or sea-water and be qualified for both types of fluids,
- The components of the C/WO system are designed to withstand transportation, shipping and handling loads to and on the MODU. They systems are provided with the necessary baskets, skids, racking stands, containers and protective caps to ensure fitness for operational purpose at all times,
- All lifting tools or handling subs for C/WO components have the same lifting profile as the work over riser (or work over riser handling subs) in order to avoid changing the elevators in between operations. In summary, it is desired to maintain the same set of elevators rigged up from picking up the TH with the Tubing Hanger Handling and Test Tool (Ref **GS EP FP 413**), until and including the Coiled Tubing Lift Frame (CTLF). If the CTLF is not used, It is accepted that the Surface Flow Tree or Surface Circulating Head

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will not have the same profile as the WOR joints,

- Analysis of the C/WO system includes all load cases and the complete rig RAOs and are subject to a review of inputs, methodology & results by a third party verification body and approval by Company. Third Party may be jointly selected,
- The offshore/onshore rotation of the equipment shall be minimized for onshore maintenance, the offshore maintenance is focused and foreseen. Contractor is responsible to perform the necessary maintenance, provide the require spare parts and consumable of all tools for the performance of the offshore operations,
- Contractor has to demonstrate to Company the provision of two years spare parts All spare parts delivery is foreseen 6 months prior starting the offshore operations.

4.4 Pressure / Temperature Classification

Unless otherwise stated in the Tender Document, the C/WO system shall:

- Be designed for working pressure and temperature per project specific requirements,
- Be designed to supply 345 bar working pressure for low pressure functions, and 690bar working pressure for HP functions from the IWOCs HPU. Additionally, Contractor may also supply alternate output regulated pressure as per their system working requirements,
- Fulfill the system water depth requirements defined in the Tender Document.

5. In Riser Landing String

Two types of In Riser Landing String are possible – the Sub Sea Test Tree Landing Sting (SSTTLS) or the Simplified Landing String (SLS). Only the SSTTLS is able to be used for Live Well operations (any activity which involves the possibility for hydrocarbons to flow to the MODU. The Project Particular Specifications determines which type of Landing String will be supplied.

5.1 Barriers Philosophy

5.1.1 Sub Sea Test Tree Landing String

Once the Tubing Hanger is landed, the annulus shall be controlled via the BOP choke or kill line with the closure of a BOP Pipe Ram on to the Ported Slick Joint of the SSTTLS. The BOP Lower Annular bag shall be closed on to the Annular Slick Joint in order to provide Secondary Function operability of the SSTT assembly.

The Riser Sealing Mandrel needs shall be demonstrated on a case by case basis taking into account the project specific parameters (such as water depth, reservoir fluid GOR, MEWHP,...) spaced out for latched or unlatched position in order to minimize the possibility of gas exposure to the drill floor in the event of gas entering the marine riser.

An evaluation of the SSTT operational limits has to be conducted between the Company and the Contractor.

As a minium dual elastomeric or metal to metal seals are utilised on all interfaces from the THRT interface to the TH to the upper of the SSTT assembly.

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5.1.2 Simplified Landing String

Once the Tubing Hanger is landed, the annulus shall be controlled via the BOP choke or kill line with the closure of a BOP annular bag onto the SLS.

In case of rig loss of position, the THRT is not disconnected (risk of getting stuck in the BOP upon riser analysis results). The primary means, in the event of a BOP Emergency Quick Disconnect, is to use the BOP shear rams to cut the Simplified Landing String at the Shear Joint.

Dual elastomeric or metal to metal seals are utilised on all interfaces from the THRT interface to the TH to the top of the SLS.

5.2 Overall Requirements

The IRLS system is designed to be run in the BOP marine riser and provide a pressure containing conduit for well bore fluids and smooth passage of the necessary well bore tools and equipment between the TH/completion and the surface vessel. All equipment is designed to withstand external hydrostatic pressure with atmospheric pressure inside.

All hydraulic and electrical functions are controlled from the Installation & Work Over Controls unit.

The system shall include the following main pieces of equipment:

- The Tubing Hanger Running Tool (THRT),
- Landing String:

Either

- The Sub Sea Test Tree Landing String (SSTLS), comprising of the Ported Slick Joint, Tubing Hanger Orientation Joint (THOJ), Sub Sea Test Tree Assy (including Latch), Shear Joint, Retainer Valve, Annular Slick Joint, & Adaptor Joint.

And/or

- The Simplified Landing String (SLS), comprising principally of the Tubing Hanger Orientation Joint (THOJ), the Shear Sub and the Annular Slick Joint, Adaptor Joint,
- An appropriate work over riser,
- A lubricator valve,
- Surface equipment, comprising of Slick Joint (Cased Wear Joint), Swivel, Surface Flow Tree (SFT) for live well operations, Surface Circulating Head (SCH), and Tension Frame (Coil Tubing Lift Frame),
- A Riser Sealing Mandrel (if applicable).

The following general functional and design requirements are applied to the In Riser Landing String C/WO system or the relevant parts of it:

- The entire Completion/Work Over String is capable of supporting the full weight of the Tubing Hanger system and the upper completion tubing string, and has adequate strength to allow retrieval of the tubing string with sufficient force to overcome total string weight and maximum expected downhole friction + 50 tonnes. Minimum load capacity is

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compatible with the tubing hanger requirement. As a base case, is a system rated to a minimum of 227 tonnes (500,000 lbs) of dynamic tension and 340 tonnes (750,000 lbs) of static tension is sufficient. The TH/THRT is not the weakest link in the system (for the SSTTLS the weakest point is located above the unlatch point),

- All components of the In Riser Landing String (including the TH with THRT) are designed to be run through an 18-3/4" BOP stack with marine riser and flex joint, and are capable of snag free passage with the flex joint deflected to an angle of 1° (on normal running operation),
- In a BOP EQD scenario, where the In Riser Landing String has been sheared at the Shear Joint, the remaining upper portion of the In Riser Landing String is capable of recovery at a flex joint angle of up to 3°,
- Hard piping / tubing is used for all hydraulic lines where practical along the SLS. The Shear Joint uses small bore pipe associated with clamps. The critical functions are the SCSSV line, and lines were trapped pressure in the sheared control lines could compromise post shear recovery operations, example THRT Latch,
- The THRT and In Riser Landing String are designed for assembly / disassembly onshore and transportation offshore in one basket (with a field connection acceptable). The THRT-SLS are designed to enable the THRT- In Riser Landing String assembly to be racked back in the derrick. Design should be such that it is possible to perform electrical and hydraulic testing of the THRT- In Riser Landing String when racked back,
- A fluid compatibility study of the control fluid with divalent brines (CaCl_2 , CaBr_2 and ZnBr_2) has to be conducted at static and flowing temperatures. If the results demonstrate solids formation a common return line to surface tank will be implemented,
- The SLS and/or SSTTLS include the same electrical connectors type that is used for the Tubing Hanger/Xmas Tree system.

5.3 Tubing Hanger Running Tool (THRT)

For details of the THRT, refer to [GS EP FP 413](#).

5.4 Sub Sea Test Tree Landing String (SSTTLS)

5.4.1 Ported Slick Joint (PSJ)

The Ported Slick Joint allows isolation of the annulus using the BOP Pipe rams, as well as providing protection to the Marine Riser in the event of a unplanned THRT Unlatch. It fulfills the following points:

- Provides a slick section for isolation of the annulus with BOP Pipe Rams, and is designed in such a way it permits to carry out a pressure test of the TH seals,
- Consists of a pipe section with integrated control lines for the Completion, THRT and TH functions,
- Outside diameter of the PSJ should be consistent with standard BOP pipe rams; this is to be confirmed by the project requirement based on the selected BOP stack. Inside diameter provides full bore access to the completion in accordance with TH maximum drift

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- It has a shoulder at the lower end to prevent loss of containment in the event that the THRT is inadvertently unlatched. BOP space out dependent, it should prevent the THRT production bore stab seals from completely dis-engaging from the TH in the afore mentioned event,
- Based on the project BOP space-out requirement the Ported Slick Joint may be located between either :
 - THRT & THOJ,
 - THOJ & SSTT,
 - SSTT Lower Valve and SSTT Upper Valve.

With the key requirement being it is below the SSTT Upper Valve.

5.4.2 Tubing Hanger Orientation Joint (THOJ)

The Tubing Hanger Orientation Joint (THOJ) allows correct orientation of the tubing hanger prior installation of the tubing hanger in the wellhead. It provides:

- The required space-out and elevation with respect to the BOP rams and the orientation helix / mechanism to the retractable orientation pin attached to the BOP stack, such that correct alignment of the tubing hanger is assured on landing,
- The alignment slot should include a fine tune alignment plate bolted onto the THOJ slot. The fine tune alignment plate is manufacture with a softer material than the BOP pin,
- A helix (to be indexed to the BOP / BOP Pin), which is able to be fully rotatable around the main body to aid THOJ Jigging operations. The Helix sleeve is then pinned / fixed onto its required indexed position located below the BOP pin outlet,
- Space-out for the Sub Sea Test Tree assembly and shear sub such that it is located inside the BOP at a suitable elevation to be able to close the drilling BOP shear rams above the THOJ. To be checked precisely with MODU BOP. Note: the spacing out of the Shear sub may be achieved with a spacer sub. The final Shear Sub dimensions and layout is part of detailed engineering once the MODU has been selected,
- If the THOJ is below the PSJ, it may provide Annulus bore access for fluid circulation (direct or reverse circulation),
- A lower connection to the Tubing Hanger Running Tool or Ported Slick Joint and an upper connection to the Sub Sea Test Tree or Ported Slick joint (depending on the required BOP space Out),
- Continuity to the hydraulics and electrical lines, and production bore. The lower connection allows change out of the THRT at rig floor without rigging down the Landing String if it is below the PSJ,
- Well production bore access for all downhole intervention toolings.

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5.4.3 Sub Sea Test Tree

The Sub Sea Test Tree:

- Incorporates two valves, where the lower valve is capable of shearing coiled tubing / wireline, and the upper valve is capable of sealing,
- Is able to cut WL/CT with electric wire inside with hydraulic close assist (size and yield value to be given as part of the project specific requirements). The SSTT Assembly is capable of sealing after the cutting operation,
- Has been qualified to satisfy the compatibility with all well's fluids and control fluids at the well flowing temperature and pressure,
- Contains a secondary means of unlatching the SSTT and close the SSTT valves,
- Seals against design pressure from above for testing of the SSTT Latch connector,
- Has pump through capability for bull heading of well,
- Contains valves capable to close in flowing well conditions. All the valves are capable to open, close and seal with atmospheric pressure or design pressure in the bore,
- Contains a chemical injection facility containing dual sealing double check valve arrangement, and enter between the upper and lower valves,
- Allows for complete flushing and cleaning of the hydraulic paths and of its own hydraulic actuators (on surface),
- Allows hydraulic continuity and full bore passage between the WO Riser and the THRT,
- Facilitates well control and safe re-entry in the event of an emergency disconnection,
- Includes an integrated connector (SSTT Latch) to facilitate quick disconnection in the event of an emergency situation, and re-entry afterwards of the running string,
- The upper interface of the SSTT which mates to the SSTT Latch assy incorporates vented couplers where necessary to ensure that the well is left in a safe state, with all THRT functions left in an as-is state with the ability to secondary control operate if necessary,
- Provides an inclined C-plate to facilitate the hook-up in the inclined rig mouse hole if relevant,

5.4.4 Sub Sea Test Tree Latch

The SSTT Latch assembly is located above the SSTT Upper Valve. It:

- Has an actively pressurised 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,
- Is possible to disconnect with the control lines pressurised. The hydraulic functions are designed with due consideration to U-tubing effects and contamination of the hydraulic system (minimise water ingress),

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- Contains a secondary or tertiary means of unlatching from the SSTT whereby pressuring up the annulus below the BOP Annular Bag / ASJ ruptures a burst disc (or similar mechanism) and operates SSTT Latch to Unlatch,
- Is designed to prevent for non intentional disconnection (i.e. a fail as is function, with controls interlock to prevent unlatch function when not in appropriate mode). In addition, the SSTT latch does not unlatch when no pressure is applied on latch line when the completion weight is hang off,
- Has a Bleed Off Valve (BOV) part of the SSTT Unlatch function, where it is possible to vent automatically through a Bleed Off Valve (BOV) the volume between the SSTT Upper Valve and the Retainer Valve,
- Is possible to reconnect without unlocking the TH and THRT,
- Is designed with the objective of preventing settlement of debris in areas with critical influence on the SSTT functionality, such as hydraulic couplers etc,
- Goes under function test and validate the EQD Unlatch function prior to running in hole.
- It does not interfere with the THRT secondary unlatch.

5.4.5 Shear Sub

The SSTTLS includes a Shear Sub between the Sub Sea Test Tree Latch and the Annular Slick Joint (ASJ), for emergency cutting of the string by BOP shear rams when the Tubing Hanger is landed inside the Wellhead HP Housing, to allow emergency disconnection of the marine riser. The Shear Sub fulfills the following requirements:

- Has sufficient strength without preventing shearing of the string with coiled tubing inside of it by use of MODU BOP shear rams. Details of coil tubing and BOP shear rams will be provided by COMPANY,
- Has sufficient strength to tolerate maximum bending moment due to vessel drift off with marine riser top and bottom flex joint angle up to 3° as a minimum. The maximum flex joint angle which can be tolerated by the shear sub due to a vessel drift off has to be calculated during the detail engineering phase in conjunction with the Global Riser Analysis,
- Load cases used to design the shear sub is submitted for approval to COMPANY during the design phase but includes as a minimum: RIH / POOH / emergency pull out (taking into account maximum completion weight + over pull – To be provided by COMPANY) / completion pressure testing, pressure testing below annular preventer and well flow back operations. Its final design is validated during detailed engineering, and once the MODU has been selected against its BOP Rams. Sufficient material is in stock to revise the design based on a shear test,
- Provides spacing out for correct location of the ASJ inside the BOP stack to facilitate proper sealing of the BOP annular preventer bag,
- Provides continuity of the hydraulic and electrical lines attached to its outside body which are designed for quick and easy replacement in the event of handling damage,

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- Control lines (electric and hydraulic) are secured around the shear joint to ensure they remain in a controlled position after severing the shear sub. This is mandatory to allow post shear recovery / fishing operations. CONTRACTOR has to demonstrate that the control line & clamping/securing device offer such functionality. Validation is made during the BOP shear test,
- The choice of either flexible or steel tubes for the control lines has to be addressed to ensure that no critical functions that should be required to vent are left in a compromised condition that would impair the recovery process, post shear scenario,
- A "Test" Shear Sub(s) has to be provided to allow a shear test, on the selected MODU, to qualify the shearing capacity & verify the shear sub design. This test Shear Sub replicates the SLS shear sub (incl. material), including the control lines and their clamps. It is terminated with 4"1/2 IF pin & box connections (so that the MODU can handle, correctly space the shear Sub within the BOP).

The Shear Sub assembly may include separate 'spacer subs' to facilitate its positioning within the BOP stack with respect to the THOJ and the ASJ.

5.4.6 Retainer Valve

It is required at the lower part of the WOR to avoid any release of production fluid and / or gas into the marine riser in case of disconnection. Design details are as follow:

- The Retainer Valve lower connection has an interface with the shear sub and upper connection has an interface with the Annulus Slick Joint / or Riser Adaptor Joint,
- The valve is capable of retaining fluid and gas in the WOR at full working pressure,
- The Retainer Valve may have a smooth outer body housing allowing the lower BOP annular to close and seal over the valve body, thus replacing the requirement for a separate Annulus Slick Joint,
- The Retainer Valve Close and SSTT Unlatch functions should be hydraulically interlocked whereby the Retainer Valve closes first, Bleed Off Valve vent opens and then the SSTT unlatches.

5.4.7 Annular Slick Joint (ASJ)

The Annular Slick Joint allows the BOP annular preventer to close and seal, in order to pressurise the annulus in the BOP down to the BOP Pipe Rams closed around the PSJ or down to the well annulus (Tubing/Casing). It fulfills the following requirements:

- Be sized to accommodate the closure of the upper and lower annulus bags at the same time,
- The outside diameter is sized to seal at the maximum expected wellhead pressure,
- Be sized for functional operation without causing any damage to the BOP element or the slick joint and prevent any excessive loads (upward / downward) being generated during pressure testing from below or during the well flowing,
- Provide continuity of the hydraulic and electric lines between the umbilical and the shear joint,

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- Be designed such that no connection (riser joints or umbilical / hard pipe connection) extends into the BOP flex joint area,
- The ASJ provides the continuity of the well bore with all requirements listed above. The bore working pressure is 690 bar (10,000 psi),
- The ASJ has smooth outer surfaces allowing the BOP annular bag preventer to close and seal over the slick external profile body. The maximum external pressure to be applied will be 690 bar (10,000 psi), dependent on the BOP annular bag capacity,
- Pressure end loads due to working pressure being applied below the annular BOP is addressed and all system sub-components designed accordingly.

5.4.8 SSTTLS Contingency Tools & Procedure

The SSTTLS:

- Is provided with contingency tools including milling tool and procedures to facilitate removal of the THRT, THOJ, SSTT and remaining lower Shear Sub should BOP shear rams have been activated,
- Is designed not to require any remedial work such as milling for recovery of the SSTTLS with a severed Shear Sub. The recovery tool should be designed to pass over the severed Shear Sub and latch on a dedicated profile below the Shear Sub,
- Is then possible to unlatch the SSTT Latch assy using secondary or emergency unlatch function. The SSTT remains in place, with the well secure under the valve assemblies,
- Upon replacement of the shear sub into the upper portion of this Landing string and above the SSTT Latch, well re-entry then follows to re-gain control of the SSTT and THRT / Completion.

5.5 Simplified Landing String (SLS)

The SLS is designed as per following requirements:

- For internal and external pressure encountered during installation and test of tubing hanger. Unless otherwise agreed with Company the internal and external pressure is not less than the working pressure,
- Stack up drawing showing the SLS inside the Rig BOP bore is issued to Company for approval,
- An orientation tolerance study is carried out to ensure compliance with requirements and agreed and approved by Company,
- It is possible to rack the SLS with the THRT in the derrick. The weight of the THRT & SLS assemblies (with any required handling tools / riser extension for racking) is verified and is below 9 Tons to ensure handling is feasible using MODU derrick racking arms.

5.5.1 Tubing Hanger Orientation Joint (THOJ)

The tubing hanger orientation joint (THOJ) allows correct orientation of the tubing hanger prior installation of the tubing hanger in the wellhead. It also provides:

- A slick section. This is designed to provide the required space-out and elevation with respect to the BOP rams and the orientation helix / mechanism to the retractable

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orientation pin attached to the BOP stack, such that correct alignment of the tubing hanger is assured on landing,

- The alignment slot should include a fine tune alignment plate bolted onto the THOJ slot. The fine tune alignment plate is manufacture with a softer material than the BOP pin,
- A 360° helix (to be indexed to the BOP / BOP Pin), which is able to be fully rotatable around the main body to aid THOJ Jigging operations. The Helix sleeve is then pinned / fixed onto its required indexed position located below the BOP pin outlet,
- Space-out for the shear sub such that it is located inside the BOP at a suitable elevation to be able to close the drilling BOP shear rams above the THOJ. To be checked precisely with MODU BOP. Note: the spacing out of the Shear sub may be achieved with a spacer sub. The final Shear Sub dimensions and layout is part of detailed engineering once the MODU has been selected,
- Annulus bore access for fluid circulation (direct or reverse circulation),
- A lower connection to the Tubing Hanger Running Tool and an upper connection to the Shear Sub,
- Continuity to the hydraulics and electrical lines, and production bore. The lower connection allows change out of the THRT at rig floor without rigging down the SLS,
- An interface that enables a recovery tool to connect and allow disconnection of the THRT from the TH post shear situation.

5.5.2 Shear Sub

The SLS includes a Shear Sub between the THOJ and the Annular Slick Joint (ASJ), for emergency cutting of the string by BOP shear rams when the Tubing Hanger is landed inside the Wellhead HP Housing, to allow emergency disconnection of the marine riser. The Shear Sub fulfills the following requirements:

- Has sufficient strength without preventing shearing of the string with coiled tubing inside of it by use of MODU BOP shear rams. Details of coil tubing and BOP shear rams will be provided by Company,
- Has sufficient strength to tolerate maximum bending moment due to vessel drift off with marine riser top and bottom flex joint angle up to 3° as a minimum. The maximum flex joint angle which can be tolerated by the shear sub due to a vessel drift off is calculated during the detail engineering phase in conjunction with the Global Riser Analysis,
- Load cases used to design the shear sub have to be submitted for approval to Company during the design phase and have to include as a minimum: RIH / POOH / emergency pull out (taking into account maximum completion weight + over pull – To be provided by Company) / completion pressure testing and pressure testing below annular preventer. Its final design is validated during detailed engineering, and once the MODU has been selected against its BOP Rams,
- Provides spacing out for correct location of the ASJ inside the BOP stack to facilitate proper sealing of the BOP annular preventer bag,