

NORSOK STANDARD
COMMON REQUIREMENTS

SUBSEA CHRISTMAS TREE SYSTEMS

U-CR-003
Rev. 1, December 1994

Please note that whilst every effort has been made to ensure the accuracy of the NORSOK standards neither OLF nor TBL or any of their members will assume liability for any use thereof.

1 FOREWORD

This standard has been developed by the NORSOK Standardisation Work Group for the widest possible national and international application.

2 SCOPE

This standard describes the minimum requirements for (purchase of) subsea X-mas tree systems, both Conventional and Horizontal. This specification is based upon API Spec 17D and RP 17G and states only the **deviation and additional requirements to these specifications**. This specification should therefore be read in conjunction with API Spec 17D and RP 17G.

- This standard covers design, fabrication, testing, delivery and documentation of X-mas tree systems. The standard may be supported by Data Sheets for specific project requirements.
- The Subsea Well System covered by this specification comprises the following principal elements:
 - Guidance System
 - Wellhead System
 - Tubing Hanger System
 - X-mas Tree System - Conventional/Horizontal
 - Running Tool System
 - Completion/Workover Riser System
 - Surface Tree.

3 NORMATIVE REFERENCES

The latest edition and current amendments of the following standard shall apply at the time of order placement, unless otherwise specifically agreed.

ISO 10423	Specification for Wellhead and Christmas Tree Equipment (replace API 6A)
API Spec 17D	Specification for Subsea Wellhead and Christmas Tree Equipment (will be replaced by ISO 13628 Part 4)
API RP 17G	Recommended Practice for Design and Operation of Completion/Work-over Riser Systems (will be replaced by ISO 13628 Part 5)
DnV cert. note 2.7-1	Lifting certificate requirements

NORSOK standards:

M-DP-001	Material Selection.
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4 DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

N.A.

4.2 Abbreviations

In addition to the abbreviation listed in API 17D the following are used in this standard:

SCSSV	Surface Controlled Sub-Surface Safety Valve
LWRP	Lower Workover Riser Package
EDP	Emergency Disconnect Package
THRT	Tubing Hanger Running Tool
ST	Surface Tree
SSTT	Subsea Test Tree
SBR	Shear/Blind Rams
SPR	Slip/Pipe Rams

5 TECHNICAL REQUIREMENTS

5.1 General

- SI units and Imperial units are used in this specification. SI units with imperial units in brackets shall be used in all documentation.

5.2 Functional and Operational Requirements

The following functional and design requirements apply:

- Material requirements shall be in accordance with NORSOK Standard M-DP-001 and the relevant NORSOK Standards referred therein.
- The X-mas tree and wellhead system shall provide a tested barrier between the reservoir formation and the environment. The X-mas tree as a complete unit is defined as one safety barrier.
- Direct vertical full bore access to both the production and annulus bores shall be provided for vertical trees.
- The system shall be compatible with an 18 ¾ inch - 10,000 psi wellhead system unless specified otherwise.
- The system shall provide fail-safe features such that any single failure will not result in an unsafe system condition.
- Necessary barrier elements (WH connector and Prod. Master Valve) shall remain intact after the tree having been exposed to the typical accident loads defined, ref. clause 5.6.
- Number of leak paths in the system shall be reduced to a minimum.
- Primary components such as valves, connectors etc. shall have sufficient reliability to meet design life criteria.
- All modules and equipment which will be handled between supply boat and rig shall have dedicated lifting equipment (slings or chains) certified according to Norwegian Maritime Directorate regulations. The lifting equipment shall in addition be designed, documented and tested in accordance with DnV "Certification Note 2.7-1".
- All modules and equipment shall be designed for safe handling onshore and offshore. All equipment shall be delivered with bumper bars or frames for transportation.
- All packages exceeding 10 tonnes shall have dedicated pad eyes for seafastening. If these pad eyes are to be used for seafastening only, they shall be clearly marked with "Sea Fastening Only". All other equipment or modules which are not suited for storing in baskets or containers, shall be furnished with facilities for seafastening as appropriate.
- All equipment shall be provided with the necessary test stands/ stumps/ transportation skids and connector protective covers required for all onshore and offshore activities.
- The equipment shall provide material compatibility with all produced, injected fluids and completion fluids as specified by Company.
- The X-mas tree system shall be designed for installation/retrieval by the completion riser (vertical tree) or drillpipe.
- Specific filling, cleaning and flushing procedures shall be provided for all hydraulic components and systems. Hydraulic lines and actuators shall be designed for through flushing and provisions for taking fluid samples shall be provided.
- The X-mas Tree System shall include a cathodic protection system.
- Provision shall be made for ROV intervention where mechanical operation or override of equipment functions are required or recommended. All installation/retrieval operations shall be carried out by remotely controlled tool packages.
- All equipment which is field assembled shall be designed for safe and efficient handling and make-up with roll and pitch of 1.5 degrees.
- Pull-in operations shall be possible to perform with the X-mas tree installed.
- The sensitivity of installation and retrieval procedures to adverse weather conditions shall be minimised.
- All equipment shall be balanced, and use of counter balance weights shall be minimised.

- Components and sub assemblies for the subsea X-mas tree configurations shall be interchangeable if functional requirements permit. This shall typically include wellhead connectors, valve blocks, valves and actuators, tree caps, running tools, chokes, control pods etc.
- The pressure containing equipment shall as a minimum comply with ISO 10423, PSL 3 requirements including fabrication, and assembly. All permanently installed equipment shall be FAT tested according to ISO 1042, PSL 4, if not otherwise stated.
- All equipment, where personnel has to climb onto modules or module stack-ups for handling, inspection, maintenance or other purposes, shall be furnished with ladders, platforms and protection as appropriate. Where components are stacked, e.g. XMT/LWRP/EDP, the ladders shall be installed giving easy access from one component ladder to the next.
- Permanent installed cylinders shall be in the retract position when the connector is locked.
- All connectors shall have position indicators clearly readable by ROV.
- The X-mas tree system modules shall be designed to avoid snagging of guidewires and ROV umbilical.
- For landing and connection modules (not for guidelineless) a 3 stage guidance system consisting of posts/wires, connector body and fine alignment pins or keys shall be used.
- Adequate protection shall be provided for all hydraulic stab couplers, male and female, to prevent particle contamination during storage, testing and transportation.
- All re-entry hubs shall be provided with lightweight ROV retrievable protection caps. The caps shall protect all seal surfaces for temporary periods.
- A minimum number of seals shall be made up subsea during installation, operation and maintenance operations. No seals surfaces shall be unprotected for extended periods of time.
- Support structures on X-mas tree, LWRP and EDP shall be designed for free standing without a skid.
- The X-mas tree shall be equipped with pressure monitoring points for the emergency shutdown system and pressure testing of valves.
- The equipment shall be designed allowing for access for both working and inspection ROV's.
- ROV grab bars shall be included wherever a ROV operation is defined. This to allow stabilised working conditions for the ROV.
- All connectors shall incorporate ability to be released mechanically by ROV/ROT in case of failure to the primary system.
- All connectors shall be designed to avoid accidental unlocking of the connectors resulting from impact loads, vibration, thermal loads and any other loads affecting the locking mechanism.

5.3 Wellhead Connector

- Rated to minimum 690 bar working pressure or to the same working pressure as its parent module.
- Flanged or integrated with the tree valve block.
- Incorporated production/injection and annulus bore stab-sub. Primary metal to metal seals and secondary resilient seals for interface with the tubing hanger are preferred, conventional trees only.
- Incorporated well proven type seal at the wellhead connector interface, facility to test the seal after landing tree onto wellhead.
- Incorporated provision for easy replacement of gasket and stab seals on BOP carrier.

- If the connector is hydraulically operated the functions shall only be available in the workover mode.
- Connector shall be fully oriented relative to the tubing hanger before stab-sub seals enter the tubing hanger stab-sub pockets, conventional trees only.
- Incorporated mechanical locking device to prevent accidental release and visual indication of whether it is closed or not.

5.4 Valves, Valve Blocks and Actuators

Valves in the production bore incl. x-over valve and choke on the production trees shall be classified according to API 14D, Class 2-3S. All other valves to Class 1-3S. Valves on gas injection trees shall be classified to Class 1, Standard Service. Valves on water injection trees to Class 1 - 3C.

- All X-mas tree gate valves shall have bi-directional sealing and be bore pressure assisted to closed position.
- Vertical valves in the annulus and production bore of the subsea tree shall incorporate a mechanical override with facilities for operation by ROV.
- Position indicators shall be incorporated on all valve and actuator functions clearly showing function status (end positions and full travel) for observations with ROV. For all functions incorporating ROV override, the position indicator shall be visible from the operating ROV with the tool in the operational position.
- Shear pins for the ROV override function shall not be used on permanently installed valves.
- Hydraulically operated valves shall include fail-safe close features in the event of hydraulic system failure.

5.5 Subsea Tree Upper Connection (vertical tree)

- Tree cap could either be Non-Pressure Containing or Pressure containing, depending on specific project requirements.
- X-mas tree cap shall land and lock onto the X-mas tree re-entry hub and it shall protect seal areas and hydraulic stabs used for the re-entry equipment.
- The X-mas tree cap may provide the hydraulic link between the control pod and the Tree functions.
- If a pressure containing tree cap is selected, hydraulic couplings on top of the tree cap shall match hydraulic couplings on the tree cap running tool for the following functions as a minimum:
 - Tree cap connector lock/unlock, if hydraulically activated
 - Tree cap seal test
 - Pressure bleed
 - Ability to be relased by ROV or ROT assistance

5.6 Tree Guide Frame

- Equipment protective frames shall allow for moonpool/splash zone guidance from top to bottom of equipment.
- Provisions for ROV docking in connection with all relevant ROV operations (overrides, monitoring unit replacement etc.).
- Protect the subsea tree and components during surface handling and subsea installation.

- Incorporate a protection cover in the structure for protection of valve actuators, and other fragile equipment. An impact load defined by 10 kJ acting on an area with a diameter of 100 mm shall be assumed. This requirement is applicable to all permanently installed equipment.
- Transfer the loads acting on the structure into the wellhead connector/wellhead.
- Permit ROV visual inspection of the X-mas tree assembly including actuator, connectors and other components.
- Provide pad eyes to facilitate offshore handling and lifting of tree with tree test skid mounted.
- Design to take impact loads generated when landing running tools and ROV.
- All the ROV tool interfaces shall be placed on one panel vertically installed on the X-mas tree such that horizontal access for an ROV is provided.

5.7 Lower Workover Riser Package (LWRP) (vertical tree)

The specification for the LWRP and EDP is covered in section 3.3 in API RP 17G, and section 912 of API 17D shall only be used if a separate Tree Running Tool Connector is designed.

- The LWRP shall have an upper and a lower disconnect point. The upper disconnect point (EDP) shall permit the workover riser to be released above the cutting/sealing point in a controlled manner. The EDP shall have an independent disconnection device in the event of failure of the primary system.
- All essential valves on the X-mas tree included SCSSV shall close if disconnection between LWRP and EDP upper connection is carried out during operation.
- The connector shall be designed to be released by ROV assistance independent of the primary system.
- All rams and ram locking devices shall be furnished with a "full travel" type position indicator which can be observed by an ROV camera.
- The LWRP shall have an injection port for chemical injection into the production bore.
- The LWRP block is considered a key element of the LWRP. It shall meet the following criteria:
 - It shall include a direct and full bore access to production bore and an annulus bore with no restrictions.
 - It shall have two ram cavities in the production bore.
 - The upper ram cavity shall feature Shear/Blind Rams (SBR) and shall cut coil tubing with braided cable inside as specified by Company.
 - The lower ram cavity shall feature Slip/Pipe Rams (SPR), hang off sizes to be specified by Company.
 - Both rams shall be hydraulically actuated, "fail in position".
 - The spacing between the SBR and the SPR must be large enough to ensure an effective tubing "fish" of 10" after cutting; i.e. spacing to be (10 + height of cavity).
 - Annulus bore shall feature cavity for "fail-safe close" hydraulically operated gate valve and must be capable of cutting wire.
 - The block shall include a Production Isolation Valve above the upper ram with feature to cut braided wire.
 - Block shall include a fail-safe close hydraulic operated X-over. It shall be possible to pump kill fluid into production bore via the annulus riser with the production blind/shear ram closed.
 - All valves shall have visual pos. monitoring and ROV override.
 - X-over shall be furnished with "fail safe close" hydraulically operated gate valve.
 - The SBR and SPR closing time shall be maximum 20 seconds.

- All gate valves shall meet same requirements as for the subsea tree valves.
- The hydraulic system for the SPR must include provisions to re-opening a locked SPR by means of ROV after a disconnect.

5.8 Tree Cap Running Tool (vertical tree)

- This tool may be combined with the Emergency disconnect package (EDP).
- Incorporate a hydraulic operated connector to connect to the tree cap re-entry hub.
- The connector shall be designed to be released by ROV assistance independent of the primary system.

5.9 Flowline Connector

- Incorporate mechanical locking device to prevent accidental release and shall have visual indicator of whether it is closed or not.

5.10 Hydraulic Control Interface

- Hydraulic couplers shall preferably have metal to metal seals.
- All hydraulic systems including piping shall be supported and protected adequately to minimise damage during testing, handling, installation/retrieval and normal operations.
- All hydraulic system piping shall be seamless.
- The size of the hydraulic system piping shall be confirmed by the tree contractor to allow correct operation of the control system with respect to valve opening/closing time etc.
- Continuous length of piping shall be used.
- All hydraulic lines shall be thoroughly cleaned and flushed before assembled and shall satisfy the applicable cleanliness requirements.
- NPTF (or equivalent) thread shall be used at the termination of the hydraulic piping at the hydraulic valve actuators, hydraulic couplers and/or other termination points.
- Multiport hydraulic receiver plates shall have adequate strength and stiffness to allow proper make-up of all the metal seal couplers.
- Multiport hydraulic receiver plates shall have alignment system provided to ensure the stab plates on other part to be correctly aligned to the receiver plate prior to engagement of the metal seal couplers.
- All hydraulic piping shall be welded to minimise possible leak paths. Hydraulic fittings i.e. end termination, shall be of Gyrolock, Swagelock or similar type up to 690 bar working pressure.

5.11 Miscellaneous Equipment

Test Stands and Fixtures

- Provide protection to the equipment during offshore handling and transportation. Accommodate up to 35 degree heel. Provide for seafastening on the rig and rig skids.
- Test stumps to comprise a mandrel to land, lock and test the respective equipment connectors and sealing arrangement.
- Test ports shall be drilled in the mandrel to enable pressure testing of annulus bore, production bore and annular gasket on the respective equipment.

- Include hydraulic coupler plates with couplers identical with the coupler plates and couplers on the respective equipment.
- All test ports and hydraulic couplers shall have hard pipe back to one common panel equipped with quick couplers. All hydraulic piping shall be equipped with isolation valves.
- Provide two removable dummy guideposts.

5.12 Subsea Tree Assembly

The X-mas tree shall be oriented by the guide posts on the guide base. It shall land, lock and seal onto the wellhead and tubing hanger (vertical tree).

- The X-mas tree shall contain necessary valves for barrier function, and as a minimum contain one production and one annulus master valve. These valves shall be fail safe close.
- Other valves may be added based upon the process or well intervention requirements.
- The total shipping weight of the X-mas tree assembly (including counter balance weights and shipping skid) shall not exceed 25 tons.

5.13 Production Guide Base (PGB) and Wellhead

5.13.1 PGB

- The PGB to 30" conductor housing interface shall include an anti rotation device with sufficient capacity to withstand all installation, operational and accidental loads. Loads shall be defined. If the protection structure takes the load this requirement will not apply.
- The guideposts shall be replaceable using ROV operated locking mechanisms.
- The guidepost locking mechanisms shall be designed for optimum protection against unintended unlocking due to snagging wires and cables.
- The guideposts should have through hole to seabed to allow passage of the guidewire anchor.
- The PGB design shall enable a ROV to inspect and clean all required areas such as connection hubs or plates.
- The wellhead system shall be designed for a Cutting Disposal System to divert spud cutting from the well to a subsea dump site area.
- Company provided anchor system shall be used for guide wires.
- Provide grouting funnel for top-up of cement, if used as Drilling Guide base.

5.13.2 Wellhead Housing

- Pressure rating shall be 10000 psi unless otherwise stated.
- Provisions for vertical locking of each separate casing and the tubing hanger are required.
- All packs-offs, seals and hangers shall be designed to allow individual retrieval of complete parts, without damaging the sealing surfaces.
- The wellhead shall be supplied with a standard corrosion cap.

5.14 Tubing Hanger System (vertical tree)

5.14.1 General

- The tubing hanger shall land, lock inside the 18 ¾" wellhead housing and seal against the casing hanger. A body seal arrangement shall also be considered.
- The OD of the tubing hanger shall allow it to be run/retrieved through an 18 ¾" BOP stack/riser.
- The tubing hanger production and annulus bore shall have stab pockets to accept the stab subs from the tubing hanger running tool and the X-mas tree. Two seal areas, one for long version and one for short version X-mas tree stab subs shall be provided.
- The tubing hanger shall provide landing nipple profiles to accept for wireline plugs in both the production and annulus bores. The actual packing bore shall be maintained in the body of the tubing hanger.
- The tubing hangers shall be supplied with a production pup piece installed and tested, prior to shipment offshore. SCSSV control line connection and tubing threads shall be specified.
- Full orientation in the wellhead shall be achieved prior to energising the TH seal arrangement.
- The hydraulic stabs in the tubing hanger shall have a design that avoids seawater ingress at the relevant water depth and shall have no recesses into which debris can accumulate, ref. section 918 in API 17D.
- The tubing hanger annulus bore shall be provided with an integrated or external attached plug catcher device.

5.14.2 Tubing Hanger Running Tool (THRT)

- The THRT shall ensure safe running, locking, testing and retrieval of the tubing hanger.
- The OD of the THRT adapter joint shall be able to pass through a 18 ¾" BOP stack.
- The tubing hanger running tool shall as a minimum have the following functions:
 - operating of SCSSV (pressure rating to be given by Company)
 - tubing hanger lock
 - tubing hanger unlock
 - tubing hanger lock indication
 - tubing hanger seal test, if required
 - tubing hanger running tool lock
 - tubing hanger running tool unlock
 - downhole pressure/temperature monitoring (if required)
- The tubing hanger running tool shall be designed such that loss of hydraulic pressure during installation or retrieval shall not result in dropping of the TH from THRT
- There shall be positive indications that the running tool is properly locked in place before running of the tubing hanger.
- Torque operated tools shall preferably be engaged by right hand torque. Specific advise shall be given when left hand torque operated tools are suggested.
- The tubing hanger running tool shall include a function for emergency release from the tubing hanger if hydraulic supply is disrupted. The tubing hanger running tool shall be designed such that pressure test of TH against BOP annular bag can be done to full "working pressure" without separating TH and THRT
- The orientation joint shall have a shoulder to react upthrust against the annular preventer if emergency disconnect is provided by pressurising bore below the annular preventer.

- The upper connection shall allow the tubing hanger running tool to be run on the workover riser.
- All stab subs and other sealing elements shall be designed with a minimum of two elastomeric seals.
- The running tool shall provide direct vertical access to both the production and annulus bores with no intermediate restrictions or deviations.
- Minimum load requirements 250 tons. (Pull-out of Tubing Hanger).
- Tool functions operated via the workover control system.
- The following tools shall be delivered in addition to the THRT:
 - **Riser Simulator Connection Tool** - This is a tool for connection of the hydraulic lines (and electrical connections required) between THRT and workover control system umbilical. It is used for functioning and testing of the TH and THRT. It might also be used for handling of THRT.
 - **Tubing Hanger Storage Stand** - The TH storage stand shall store the TH in vertical position.
 - **Tubing Hanger Running Tool Storage Stand** - The THRT storage stand shall store the THRT in vertical position.
 - Emergency tubing hanger retrieving tool (ETHRT).

5.15 Workover Riser (vertical tree)

This clause is based on RP 17G - Recommended practice for Design and Operation at Completion/Workover Riser Systems.

- The workover riser shall be used to run and retrieve the tubing hanger and the X-mas tree/LWRP. The bores shall be designed to allow for unobstructed passage of internal tool strings.
- The workover riser shall include the production and annulus tie-back string which will allow for well operations/interventions.
- The workover riser system shall contain the following type of riser joints:
 - Stress joint
 - Standard riser joint
 - Riser pup joints
 - Riser tension joint
 - Surface tree adapter joint
 - Through bore riser handling sub.
- The riser string shall have standard 45 ft. long riser joints and pup joints to facilitate space out.
- The pup joints shall be identical to the standard riser joint, with effective lengths of 15 feet, 10 feet and 5 feet.
- The riser with the tubing hanger umbilical shall be able to pass inside drilling riser, dimensions shall be specified.
- The workover riser may include integrated clamps for proper attachments of the umbilicals.
- The stress joint shall include a bolted or clamped connection (or other means) for attachment to the EDP. Upper connection of the stress joint shall be a standard riser coupling.
- The stress shall be evenly distributed over the length of the stress joint.
- The riser coupling shall be provided with a simple but highly effective connection. Production bore connection shall be of Lock-Nut/Union-Nut design and stub box for annulus.
- The riser coupling shall have double resilient seals for each bore.

- The surface tree adapter joint shall provide the interface between the riser tension joint and the surface tree and should have an external casing for protection of riser couplings and umbilical when they pass through the rotary table.

5.16 Surface Tree (ST)

The surface tree shall be of a single through bore design. The ST provides vertical access for wireline tools and coiled tubing. Facility to shut in production flow and kill the well shall be included in design.

The ST shall comply with the following requirements:

- The ST shall incorporate the following valves:
 - Hydraulic operated production and annulus wing valves, fail safe close with bi-directional sealing. Valve size shall be specified.
 - Manual operated production and annulus master or swab valves, with bi-directional sealing. Valve size shall be specified.
- The top connection of the handling sub shall be an Otis Quick Union, interfacing the wireline/coiled tubing equipment. The design shall allow for use of a coiled tubing unit.
- The ST shall be suspended in the rig travelling block using extended bails. The bails shall be attached to the ST handling/suspension sub by an elevator compatible with the handling sub profile.
- The ST shall have production and kill outlets set 90 °. down.
- All the valves shall have visual position indicators.
- Production wing valve on ST shall close within 10 seconds in case of a Production Shut-Down.
- The ST shall have protective frame and platform for operation of manual valves.
- The ST shall be designed to allow a pull load equal to 250 MT from rig draw work.
- ST to surface tree adapter joint shall be designed with riser connection.
- The ST shall have pressure monitoring functions in the production bores.

5.17 Horizontal Subsea X-mas Tree System

The requirements given in this chapter is only valid for Horizontal Subsea X-mas Tree Systems, but the requirements given for the conventional tree system shall be followed for horizontal systems if not otherwise stated.

5.17.1 General

The horizontal X-mas tree is a single bore design. Well fluid is controlled by lateral gate valves externally mounted or integral as part of the X-mas tree block.

The X-mas tree valves provide the facility to shut in produced flow, and allow communication of annulus bore to production/intervention vessel (or rig), communication between production and annulus and facilitate injection of various types of fluid inhibitors etc.

An internal tree cap is installed above the tubing hanger and internally inside the X-mas tree.

After tubing hanger installation, communication to the SCSSV is achieved by radially extended stab couplers. Stab couplers shall be moved to the extended or retracted position using dedicated hydraulically or ROV operated "fail as is" actuators.

The internal tree cap shall be landed, sealed off and locked above the TH and inside the X-mas tree. The design shall be based on running and retrieval through the BOP and marine riser system.

The internal tree cap shall contain a single through bore with the bore containing a profile suitable for the installation, locking and sealing of a wireline run plug, or an alternative pressure containing device such as a ball valve. This bore shall be of sufficient ID to allow the retrieval of the tubing hanger plug and give full access to the tubing without the requirement to pull the internal tree cap. The component shall be landed, sealed off and locked above the tubing hanger inside the X-mas tree body.

The internal tree cap together with the wireline plug, or alternative device, shall provide a secondary barrier element in addition to the tubing hanger wireline installed plug.

Above the production bore side outlet, a wireline set plug shall be installed to achieve vertical wellbore isolation.

The tubing hanger running tool together with the subsea test tree (SSTT) shall be used to install and retrieve the tubing hanger, and be able to lock and unlock the tubing hanger, test necessary seals, operate the SCSSV and give access to downhole gauges.

The Interface between SSTT and TH shall allow for standardisation between system suppliers.

5.17.2 Tubing Hanger (TH)

The tubing hanger shall be run, oriented, landed and locked in the x-mas tree in a single trip.

When TH is landed, a metal-to-metal seal with elastomeric back-up from production side outlet to the production annulus shall be established.

TH orientation shall be achieved by a key/helix system where the key forms part of the TH body.

After the TH is installed, seal integrity of energised seal elements shall be hydraulically verified. Test pressure shall be applied in the direction of flow.

Vertical access shall after successful installation be isolated with a wireline retrievable plug. A metal-to-metal seal with elastomeric back-up for the wireline set plug shall be included.

The TH shall be fully oriented before the TH seals are set inside the x-mas tree.

The TH shall be supplied with an internal isolation sleeve to allow circulation of the production string during running/retrieval.

A non sealing wear bushing shall be supplied to protect WL plug profiles during well entries.

5.17.3 Subsea Test Tree (SSTT)

The following design requirements shall apply:

- The SSTT shall include an integrated quick disconnect package for the running string. The quick disconnect connector shall have an active pressurised latch function throughout complete operation.
- Consideration shall be given to designing the SSTT to THRT interface as a space out joint to allow a pipe ram to be closed in between the TH and SSTT. The space out joint shall include integrated control lines required for the THRT and TH functions.
- The SSTT integrated disconnect package shall be designed to allow for re-entry with full hydraulic communication. Equipment shall be designed allowing space out by tagging on a closed shear ram.
- The SSTT shall be designed to allow the BOP shear ram to be closed above the SSTT without the SSTT being disconnected.
- The capacity of the hydraulic control system accumulators shall be designed with sufficient capacity to allow for a close-open-close sequence without the requirement for recharging.
- The SSTT shall include an injection line/port with a dual sealing/backflow valve arrangement, with the injection point being between the valves.
- The SSTT valves, both isolation and cut/seal shall be designed fail safe close.
- Maximum allowed disconnect time shall be 45 sec. This applies from activation to complete disconnect of running string.
- The cutter valve shall be designed and qualified cutting coiled tubing with braided cable inside as specified by Company.
- The SSTT shall include independent primary and secondary disconnect feature.
- The SSTT shall be designed to be pump through when in closed position.

5.17.4 X-mas Tree

The subsea horizontal tree body shall be 690 Bar (10000 PSI) WP. The WP of the remaining components shall be as specified by Company.

The production annulus shall be isolated from the environment by minimum 2 off individual seals. The positioning of the seals and stinger shall provide sufficient flexibility to accept maximum and minimum tolerance build-up on the setting height of the production casing hangers.

Surface pressure testing of the x-mas tree valves shall be performed without filling the x-mas tree throughbore with test fluid or use of a 18 $\frac{3}{4}$ " high pressure cap.

The x-mas tree shall be designed allowing for throughbore drilling of the 8 $\frac{1}{2}$ " section.