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Foreword

This IOGP Specification was prepared by Joint Industry Project 33, Standardization of Equipment Specifications for Procurement, organized by IOGP with support by the World Economic Forum (WEF). Seventeen key Members from WEF and IOGP membership participated in JIP33 with input from the subsea tree equipment suppliers in an effort to leverage and improve industry level standardization. The scope of work has been to harmonize procurement specifications from the seventeen participating Members and develop one agreed and jointly approved specification building on recognized industry and/or international standards. This is one of the three initial specifications to prove this concept.

Following agreement of the relevant JIP33 sub-team and approval by the JIP33 Steering Committee, the IOGP Management Committee agreed to the publication of this specification by IOGP. The next step is for the individual operating companies to evaluate this specification and consider whether to replace their own specification with this joint specification and thereby achieve real standardization across the oil and gas industry. This specification applies to its participating companies and hopefully many more WEF and IOGP Members.

Introduction

a. Supplementary requirements for Subsea Trees are based on Specification for Design and Operation of Subsea Production Systems – Subsea Wellhead and Tree Equipment, API 17D, Second edition, May 2011 including Addendum 1, September 2015 and Errata 7, October 2015.

b. Requirements of this Specification are modifications to API 17D and are not to be interpreted to reduce requirements defined by API 17D.

c. Modifications to API 17D are identified as Add, Modify or Delete.

d. Paragraph numbers in this Specification correspond to API 17D.

e. Paragraphs of API 17D that are not revised remain applicable.

f. Suppliers can offer designs that exceed these requirements.

g. This specification drives standardisation to meet the majority of applications in order to reach agreed industry solutions. It focuses on the most common functional design requirements.

This Specification presumes that a compilation of documents will be used for the definition, enquiry and purchase of API 17D subsea trees, which will consist of part, or all of the following:

– S-561, Supplementary Requirements to API 17D Subsea Trees.
– API 17D subsea trees requisition (Purchase Order), with required documentation, quality assurance and inspection attachments.
– API 17D data Sheet(s).

Supporting documents requirements can be based on the following documents which are informative only:

– IOGP S-561L, Supplier Deliverable Requirements List (SDRL) for API 17D Subsea Trees.
– IOGP S-561Q, Purchase Order Quality Requirements (POQR) for API 17D Subsea Trees.

The following requirements are not detailed within this Specification and will be identified in the Requisition, or as an attachment to the Requisition:

– Health, safety and environmental management requirements.
– Packing, preservation, marking and shipping requirements.
– Spare parts.

Unless defined otherwise in the Requisition, the order of precedence (highest authority listed first) of the codes and standards shall be:

1. Local statutory codes and regulations.
2. International statutory regulations.
3. Data Sheets.
4. User documents.
5. This IOGP Specification.
6. Referenced international codes.

1 Scope

<u>Add to 1</u>

a. The scope of this document includes requirements for subsea tree systems.

b. This specification addresses scope as per API 17D but does not include the following:

   1. Wellheads.
   2. Mudline suspension.
   3. Drill-through mudline suspension and drill through mudline suspension equipment.
   4. Tooling and skids.
   5. Electric actuated trees.

c. Detailed requirements have not been included for components outboard of the core tree. This includes design of choke, tree frame, completion guidebase (flowbase) or tubing head (tubing head spool).

2 Normative references

<u>Add to Normative References</u>

API 6A, Specification for Wellhead and Christmas Tree Equipment.

API 6AV1, Specification for Validation of Wellhead Surface Safety Valves and Underwater Safety Valves for Offshore Service.

API 17G, Recommended Practice for Completion/Workover Risers, Revision 3 working draft 6.

API RP 17N, Recommended Practice for Subsea Production System Reliability and Technical Risk Management.

ASTM A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.

DIN 3015, Fastening clamps – Block clamps.

DNVGL-RP-0034, Steel forgings for subsea applications.

ISO 8434-2, Metallic tube connections for fluid power and general use – Part 2: 37° flared connectors.

SAE J514, Hydraulic Tube Fittings – Part 1: 37° Flared Fittings.

3 Terms, definitions, abbreviated terms and symbols

3.2 Abbreviated terms and symbols

<u>Add</u>

CP cathodic protection

JIC joint industry council

LP low pressure

PCV production choke valve

PIV production isolation valve

SCM subsea control module

SDSS	super duplex stainless steel
TH	tubing hanger
THS	tubing head spool
TRL	technology readiness level
XO	cross-over

4 Service conditions and production specification levels

4.2 Product specification levels

Modify 4.2

a. Components of equipment shall be designed and manufactured suitable for API 17D PSL 3G service.

b. Selected component and final tree assembly gas testing requirements are detailed in clause 6.3 of this Specification.

5 Common system requirements

5.1 Design and performance requirements

5.1.1 General

5.1.1.1 Product capability

Add to 5.1.1.1

The equipment supplier shall provide the TRL of each major subassembly, in accordance with the requirements of API RP 17N.

5.1.2 Service conditions

5.1.2.2 Temperature ratings

5.1.2.2.1 Standard operating temperature rating

Add to 5.1.2.2.1, Before Fourth Paragraph

a. To account for Joule-Thomson cooling, pressure-containing and pressure-controlling metal components downstream of the production choke shall be subjected to Charpy impact testing at/or below −46°C (-51°F) per ASTM A370 with acceptance criteria for low alloy steel as per DNVGL-RP-0034. This shall include the choke body and out to and including the tree tie-in hub/flange/connector.

b. For gas lift service, the equipment in the flow path including tree, TH and THS, low temperature requirement shall be the same as for the rest of tree, i.e. there is no need for lower temperature class.

5.1.2.3 Material class ratings

5.1.2.3.2 Material classes

Add to 5.1.2.3.2

a. Pressure containing components exposed to well bore fluids in production flow path shall be material class HH (including and up to the XOV) as detailed below, with the exception of SDSS components as detailed in 5.1.2.3.2.d.

   1. For vertical tree, full production bore above the PSV up to and including the re-entry mandrel gasket profile.

   2. For horizontal tree, tubing hanger bore including penetrations into the tree and tubing hanger between the upper and lower crown plugs, and extending out to and including the isolation valve.

b. Annulus and other pressure-containing components within annulus flow path shall be material class EE.

c. Chemical injection ports into the production flow path shall be material class HH out to and including the isolation except for chemical injection porting through the tubing hanger which shall be material class EE. All other chemical injection ports shall be material class EE out to and including the isolation.

d. The use of SDSS is not prohibited within an HH system for sensor flanges/housing, flow lops and small bore injection isolation valves. The supplier may recommend this material for review and approval

5.1.4 Miscellaneous design information

5.1.4.8 Cathodic protection

Add New Subclause

5.1.4.8.4 Cathodic protection design shall take into account all connected items not having an independent cathodic protection system. Cathodic protection system shall be provided on the tree frame, tubing head frame and completion guidebase. The cathodic protection system of each assembly shall provide protection to one half of flying leads and well jumpers connected to that assembly. Well drain current shall be allocated to the lowermost assembly in the stack up.

Add New Subclause

5.1.4.8.5 Cathodic protection system shall be designed for the design life only, with no provision for an additional period when the CP system is active prior to operation (e.g. wet storage).

Add New Subclause

5.1.4.9 Electrical continuity

a. Designs shall ensure electrical continuity by provision of continuity bonding among assembled components of subsea equipment which is protected by the cathodic protection system. Any components constructed of metals not compatible with applied CP levels shall be electrically isolated from the CP system, unless equipped with alternative measures such as high-performance coatings.

b. The anti-fouling properties of copper based alloys shall be considered ineffective where they have continuity with the CP system. In particular, copper filters on sea chests shall be isolated from the CP system.

c. Components constructed of alloys resistant to seawater corrosion under the anticipated service conditions (including temperature, galvanic and crevice affects) shall not require electrical continuity with the cathodic protection system but may be connected to it.

d. Braided stainless steel straps shall be designed, installed, and tested if reliable electrical continuity is not ensured. The cathodic protection system shall be designed so that vibration does not cause continuity faults.

e. Non-welded connections within component assemblies shall be tested to verify electrical continuity or electrical isolation as appropriate. Acceptance criteria in Section 5.4.8 shall be met.

Add New Subclause

5.1.4.10 Monitoring

Designs shall facilitate monitoring of CP potentials of subsea equipment and anode wastage using ROV equipment. CP monitoring location shall be identified which provides a representative potential and is not located immediately adjacent to an anode. This may be an uncoated patch on the tree frame which provides a contact point for an ROV CP probe.

5.1.7 Validation testing

Add to 5.1.7

For validation testing guidance, see Annex P.

5.2 Materials

5.2.1 General

Add to 5.2.1

Materials in contact with wellbore fluids, injection fluids, control fluids, workover/drilling fluids, test fluids or seawater, shall be chemically compatible with fluids to which they are exposed by design.

Add New Subclause

5.2.6 Seal requirements

a. Static seals assembled and tested at the factory do not require a secondary seal element. Examples are bonnet gasket, BX gasket.

b. Wellhead gasket and flowline connection gaskets do not require a secondary seal element.

c. All other metal-to-metal seals shall have a secondary seal element which may be non-metallic (e.g. production seal stabs, tubing hanger OD seals) and which may be combined into one sealing assembly.

d. Seals shall not be considered as metal-to-metal unless the metal-to-metal sealing element has been validated independently of any non-metallic element.

e. Non-metallic seals made-up subsea shall have a secondary non-metallic seal element, except for:

   1. Isolation sleeve seal to wellhead.

   2. Where there may be issue due to hydraulic lock or trapped pressure.

f. Pressure containing seals on permanent equipment shall be metal-to-metal except as per examples below where non metal-to-metal seals are acceptable:

1. For vertical tree systems, non-metallic may be used for pressure-containing tree cap, tubing head spool isolation sleeve and tubing hanger external seals.
2. For horizontal tree systems, non-metallic may be used for XT isolation sleeve and TH seal above gallery.
3. Valve and choke stem primary seals may be thermoplastic. Secondary seals may be thermoplastic or encapsulated elastomeric seal.

5.4 Quality control

Add to 5.4

Purchaser inspection and surveillance requirements shall be in conformance to the Purchase Order Quality Requirements (POQR) if included in Purchase Order.

Add New Subclause

5.4.9 Interface testing

Where tooling can be affected by coating or insulation proximity, interface verification shall be performed after coating/insulation is applied.

Add New Subclause

5.4.10 Bolting

For pressure containing bolting, a process shall be used for indication of proper bolt make-up after initial assembly and again after shell test (e.g. once torqued, nuts may be marked).

Add New Clause

5.7 Documentation

Documentation shall be in conformance to the Supplier Deliverable Requirements List (SDRL) if included in Purchase Order.

6 General design requirements for subsea trees and tubing hangers

6.1 General

6.1.1 Introduction

Add to 6.1.1

Tree system shall be designed for 25 year life.

6.1.2 Handling and installation

Modify 6.1.2, Second Sentence of Second Paragraph

All equipment assemblies shall be balanced within 1° in the as-run condition.

Add to 6.1.2

Eccentrically loaded (unbalanced) equipment shall be balanced within 1° when made up to offset running tool.

6.1.3 Orientation and alignment

Add to 6.1.3

Supplier shall ensure that the system tolerances enable initial orientation and alignment while simultaneously protecting seal and seal surfaces during landing, entering or mating of the equipment packages.

6.1.6 Safety

Add to 6.1.6

a. Pre-installation seal changeout shall not require working under hanging loads.

b. Anti-skid/non slip surface shall be provided on all surfaces where a foothold is required during assembly, testing and pre-installation activities.

6.2 Tree valving

6.2.1 Master valves, vertical tree

Modify 6.2.1

Production (injection) master valve shall be integral to the tree body and shall be actuated fail-closed.

6.2.2 Master valves, horizontal tree

Modify 6.2.2

Production (injection) master valve shall be integral to the tree body and shall be actuated fail-closed.

6.2.3 Wing valves, vertical tree

Add to 6.2.3

a. Production (injection) wing valve shall be integral to the production wing block or the tree body and shall be actuated fail-closed.

b. Annulus wing valve shall be integral to the annulus block or the tree body and shall be actuated fail-closed.

6.2.4 Wing valves, horizontal tree

Add to 6.2.4

a. Production (injection) wing valve shall be integral to the production wing block or the tree body and shall be actuated fail-closed.

b. Annulus wing valve shall be integral to the annulus block or the tree body and shall be actuated fail-closed.

6.2.5 Swab closures, vertical and horizontal tree

Add to 6.2.5

On vertical trees, provision shall be made for swab valves to be manually or hydraulically actuated in workover mode. Purchaser shall specify.

6.2.6 Crossover valves

Add to 6.2.6

There shall be a crossover valve and it shall be actuated fail-closed.

6.2.7 Tree assembly pressure closures

Add to 6.2.7

a. PIV is a valve that can isolate the production flow and is downstream of the production choke.

b. Provision shall be provided for inclusion of either manual or remotely actuated PIV. Purchaser shall specify manual or remotely actuated PIV requirement.

6.2.8 Production (injection) and annulus flow paths

Add to 6.2.8

There shall be provision for two options for crossover access into the production bore. Purchaser shall specify either:

a. Inboard of the PWV.b. Between the PWV and PCV.

6.2.9 Production and annulus bore penetrations

Modify 6.2.9

a. All penetration isolations inboard of wing valves shall be integral or bolted to the block.

b. Options for production and annulus bore penetration isolations (replacing Figure 4 in API 17D) shall be as follows. Purchaser shall specify options and can have mix of 1 and 2 on the same tree:

    1. Chemical injection isolation shall consist of a single remotely actuated gate valve plus a check valve located between this valve and the block.

    2. Two remotely actuated gate valves, one of which may be panel mounted.

6.2.11 Downhole chemical-injection line penetrations

Modify 6.2.11

Downhole chemical injection isolation (replacing Figure 5 in API 17D) shall be same as in clause 6.2.9.b.

6.3 Testing of subsea tree assemblies

6.3.2 Factory acceptance testing

Add to 6.3.2

a. Valves, including small bore injection isolation valves (including check) and chokes shall be PSL 3G tested as per “testing for PSL 3G equipment - section 5.4.6”. There is no requirement for back seat test. There is no requirement to gas test valves in hydraulic circuits.

b. Tubing hangers do not require gas testing at FAT either internally, or on external seals. TH interface with tree/THS does not require gas testing at FAT.

c. Production and gas injection tree final assemblies shall be submerged gas tested. Hold period for this test shall be 1 hour after stabilisation from submersion. Acceptance criteria shall be no bubbles during the hold period.

Add New Subclause

6.6 Tree configurations

6.6.1 Pressure and temperature sensors

a. XT shall include provision for a single housing in the following locations. Exact sensor population to be specified by Purchaser:

1. Between PMV and PWV.
2. Between PWV and PCV.
3. Production bore downstream of choke.
4. Between AMV and AWV.
5. Outboard of AWV. Can be out-with wing block.

b. Single housings shall allow for either single or dual sensor elements.

c. The gap between the sensor nose and the associated port shall be sized to avoid vortex induced erosion.

Add New Subclause

6.6.2 Thermally induced pressure changes

Pressure integrity shall not be compromised due to thermally induced pressure changes in trapped volumes. All trapped volume analysis shall account for the various fluid properties contained. Areas requiring analysis shall include:

a. Isolated chambers used for testing secondary barriers (e.g. gasket test chambers).

b. Cavity between crown plugs in HXT and area above swab valves but below tree cap in VXT.

c. Other areas which may be isolated (e.g. between valves on the XO loop, and areas between dual seals).

d. Unused, plugged off or isolated functions (e.g. unused downhole penetrations).

Add New Subclause

6.6.3 Blockage avoidance

Production tree shall be configured to minimize the possibility of hydrates forming by the following:

a. Minimize the length of dead leg bores that intersect the production flowpath.

b. Orient injection ports and gauge bores to be self-draining. Horizontal penetrations shall enter into the top half of the bore, i.e. at or above the 9 and 3 o’clock positions, to be considered self-draining.

Add New Subclause

6.6.4 Chemical injection/control line provision

Tree shall include provision for the following functionality. Features not required may be blanked, or not machined. For dual bore VXT, total number of downhole functions may be reduced from those detailed below.a. Downhole control

1. 5 off hydraulic downhole lines for intelligent well/SCSSV (Valve and porting to be at minimum equal to 3/8 in tubing).

2. 2 off electrical or fibre optic.

b. Chemical injection

1. Hydrate inhibition lines (3/4 in valve with 3/4 in bore port minimum):
   - Between PMV and PWV.
   - Outboard of PWV or PCV.
   - On annulus side of XOV.
2. 2 off chemical injection lines between PWV and PCV (Valve and porting to be at minimum equal to 1/2 in tubing).
3. 2 off downhole chemical injection (Valve and porting to be at minimum equal to 3/8 in tubing).
4. For subsea tree cap injection, see clause 7.13.

<u>Add New Subclause</u>

6.6.5 Horizontal tree systems

a. The HXT with SCM, sensors, etc. shall be suitable for through bore drilling of bottom hole sections using a 8 1/2 in bit. During drilling or other downhole operations, protection of the HXT internals, such as seal areas and landing / locking profiles for the TH, shall be provided by means of bore protector.

b. An access port to the cavity between the crown plugs shall be provided. The following functions and features shall be assigned to this port:

1. Flow-by area when setting the upper crown plug.
2. Test port to verify the sealing ability of crown plugs and potential bleeding of the cavity between the upper and lower crown plugs. Test line to be fitted with a ROV operated isolation valve.
3. Test line shall be tolerant for debris with respect to bleed back of contaminated fluid during setting of plugs. Debris tolerance may be addressed using downward drilled ports in TH body and gate valves rather than needle valves.

c. Access to the TH gallery seal shall be provided.

1. Test port to test the sealing ability of penetrators and upper and lower gallery seals.
2. Pressure monitoring/potential bleeding of the cavity to be performed by ROV, online monitoring is not required.

<u>Add New Subclause</u>

6.6.6 Insulation provision

Tree system shall provide facility in geometry for thermal insulation.

7 Specific requirements – Subsea-tree-related equipment and sub assemblies

7.3 Threaded connections

<u>Modify 7.3</u>

Threaded connections shall not be used on chemical injection lines on any of the permanently installed equipment. Hydrate inhibition lines not accessing tree bores may be threaded (e.g. wellhead connectors).

7.5 Studs, nuts and bolting

7.5.5 Make-up torque requirements

Add to 7.5.5

Where coatings are used that are not specified in API 17D Annex G for bolt torque make-up, the supplier shall provide test documentation on request to verify coefficient of friction values used are accurate for the application.

7.8 Tree connectors and tubing heads

7.8.1 General

7.8.1.2 Tree/tubing head spool connectors

Add to 7.8.1.2

a. Provision for hydrate prevention and inhibition for connectors shall be provided.

b. It shall be possible to replace the connector gasket without retrieving the connector to surface.

c. The test port shall be fitted with ROV operated valve to provide the ability to test the connector gasket sealing. The valve shall have a pressure rating corresponding to the rating of the tree system. Gasket test port isolation valve shall be bolted to the block.

7.8.2 Design

7.8.2.2 Load/capacity

Add to 7.8.2.2

Performance requirements for normal, accidental and extreme loads shall be as per API 17G Revision 3 working draft 6 or later edition.

7.8.2.4 Secondary release

Add to 7.8.2.4

a. Connector shall include a secondary unlock system independent of the primary system.

b. The secondary unlock system shall be designed such that the connector will not unlock upon exposure of the unlock line to environmental pressure.

c. Secondary unlock force capacity shall be the same as or greater than the primary unlock force.

Add New Subclause

7.8.4 HXT/THS isolation sleeve

a. The isolation sleeve isolates the wellhead to the HXT/THS in order to enable the pressure test of the 18 3/4 in wellhead gasket with a minimal volume.

b. The following design requirements shall apply:

    1. The isolation sleeve shall provide pressure sealing above the wellhead gasket (in the spool/body) and below (in the wellhead system).

    2. The isolation sleeve shall be capable of withstanding HXT/THS working pressure internally and externally.

7.10 Valves, valve blocks and actuators

7.10.2 Design

7.10.2.1 Valves and valve blocks

7.10.2.1.1 General

Add to 7.10.2.1.1

a. Valves, including small bore injection isolation valves (including check) shall be designed, manufactured and tested suitable for API 6A/API 17D PSL 3G service.

b. Tree gate valves in production and crossover bores shall be designed to operate in accordance with the “sandy service” classification. These valves shall conform to API 6AV1 Class II.

c. Gate valves shall be designed to seal bi-directionally.

d. Large actuated gate valves (2 1/16 in nominal bore and larger) shall accommodate ROV linear override.

e. Penetrations shall not be permitted for the purpose of greasing, back seat testing or for testing secondary stem seals.

f. Stem seals shall be designed to function under all combinations of internal and external pressure including those during deployment. Where pressure may become trapped between seals, the design shall ensure the pressure can be relieved without damaging the seals or does not adversely affect the function of the valve.

7.12 Re-entry interface

7.12.1 General

7.12.1.3 Integral or non-integral

Modify 7.12.1.3

Upper hub/mandrel shall be integral to the tree spool/block.

7.12.2 Design

7.12.2.2 Re-entry interface upper connection/profile

Add to 7.12.2.2

a. For a horizontal tree/THS, the upper mandrel shall be an H4 profile.

b. H4 mandrels shall be designed to accept a contingency gasket that seals in a different location than the primary gasket.

c. On HXT/THS, mandrel shall facilitate a funnel down BOP connector with swallow of 1 040 mm (41 in) below mandrel top and diameter of 1 730 mm (68 in).

7.13 Subsea tree cap

7.13.1 General

7.13.1.2 Non-pressure-containing tree cap (debris cap)

Add to 7.13.1.2

a. Debris cap shall cover and protect tree/THS re-entry mandrel.

b. Debris cap shall be mechanically set and latch.

c. Debris cap shall accommodate use of subsea corrosion inhibitor.

d. If a parking spot for the debris cap is included in the tree it shall provide a method of securing the cap to prevent movement. Load cases shall include transportation, handling, installation and accidental conditions e.g. tree lowered too fast or dropped.

Add New Subclause

7.13.1.4 VXT pressure containing tree cap and tooling

a. Tree system shall be designed to enable circulation through the vent lines to be certain that there is no trapped pressure before removal. This may be achieved in the tree cap or through porting into the cavities below the tree cap.

b. Tree cap shall be capable of wire, drill pipe or ROV installation and retrieval including sufficient overpull during installation and pulling margin during retrieval. Combinations of these methods are also acceptable. Supplier shall provide normal and maximum retrieval load capacity.

c. Production and annulus bores shall be individually isolated.

7.15 Tree-guide frame

Add to 7.15

The requirements of this section shall also apply to the THS guide frame/structural frame.

7.15.2 Design

7.15.2.1 Guidance and orientation

Add to 7.15.2.1

a. Tree (or tree running tool) shall provide for ROV guidance for wire installation.

b. Tree/THS connector and guide funnel angles shall be designed to prevent contact with the ring gasket (where previously placed on top of mandrel) during installation to accommodate misalignment up to 3°.

7.15.2.2 Handling

Add to 7.15.2.2

Tree shall accommodate fastening for transportation including sea-fastening.

7.15.2.3 Loads

Add to 7.15.2.3

A pressure barrier component, or part of such, shall be protected or designed to tolerate dropped object impact loads as per API 17A.

7.17 Tree piping

Add to 7.17

The requirements for this section shall also apply to piping on the completion guide base and THS.

7.17.2 Design

Add to 7.17.2

a. Crossover piping shall be minimum of 2 in nominal schedule XXS. When crossover is drilled in the forged body, the minimum ID shall be 1,50 in (or metric equivalent).

b. Piping shall be resistant to flow induced vibration.

7.20 Tree-mounted hydraulic/electric/optical control interfaces

7.20.2 Design

7.20.2.2 Size and pressure

Modify 7.20.2.2

Minimum tube size shall be 3/8 in OD.

7.20.2.6 Small bore tubing and connections

Add to 7.20.2.6

a. For specific chemical injection requirements, see clause 7.3 of this Specification. Clauses 7.20.2.6.e to 7.20.2.6.i also apply to chemical injection tubing.

b. Mechanical connections shall provide leak tight performance for life of field and shall be validated for relevant load cases including vibration from transportation, shock loads, pressure fluctuations and production loadings. Solutions may be achieved by one of the following:

   1. A cone and threaded metal-to-metal axially loaded non-rotating seal face fitting with anti-vibration collar.

   2. 37 degree cone seal (JIC) fittings, conforming to SAE J514 (ISO 8434-2) up to 41,4 MPa (6 000 psi) design pressure.

   3. Twin ferrule compression fittings.

c. Rotational back-off preventative measures shall be used at all mechanical fittings. Coned and threaded tube anti-vibration collars alone do not meet this requirement.

d. Tubing runs to tree connectors shall be accessible such that they can be cut to release locked in fluid.

e. Transitions between tubing of differing wall thicknesses shall be minimised. Where required, transitions between tubing of different wall thickness shall be achieved using a purpose built transition adaptor.

f. Tubing shall be seamless.

g. Tubing joints shall be butt-welded using automated welding equipment. Tubing unions with mechanical fittings shall not be allowed except for LP return lines or bulkhead union. Socket weld connections shall not be used.

h. Tubing runs shall be supported with sufficient and appropriate clamps as defined in Table 38. Clamps shall conform to DIN 3015.

Table 38 - Maximum allowable distance between tubing clamps

Tube OD		Maximum allowable distance	
mm	in	mm	in
10 to 12	3/8 to 1/2	600	24
14 to 22	5/8 to 7/8	1000	40
25	1	1 500	60

Modify 7.20.2.6

i. Tubing runs shall be one piece from starting point to ending point wherever possible.

Add New Subclause

7.20.2.11 Secondary release

Where horizontal hydraulic/electric/fibre optic penetrations are required between HXT and TH, a secondary release mechanism shall permit disengagement of the penetrator in the event of a malfunction which prevents normal (linear) retraction of the stem.

7.21 Subsea chokes and actuators

7.21.1 General

Add to 7.21.1

a. Chokes shall be designed, manufactured and tested suitable for API 6A/API 17D PSL 3G service.

b. Subsea chokes shall be ROV insert retrievable type, unless choke is mounted on a retrievable package.

c. Chokes shall have external position indications that are easily visible by ROV.

d. Choke insert locking mechanism shall have a secondary release feature or ROV access for cutting in a clamp arrangement.

e. Choke actuator shall have an ROV override.

9 Specific requirements – Subsea tubing hanger system

9.1 General

Add to 9.1

Horizontal tree type tubing hanger shall be of dual crown plug design.

9.2 Design

9.2.1 General

Add to 9.2.1

a. TH lock down mechanism shall be designed to prevent moving of the TH actuator ring resulting from any loads acting on TH. If a self locking taper type of mechanism is used to lock the TH into the HXT, a secondary mechanical locking arrangement shall be incorporated as back-up.

b. Impact load of the pin/key onto the helix/slot shall be checked to ensure that torque loading on the helix or strength of the pin is not exceeded. Installation loads capacity of the pin onto the helix shall be provided.

c. Tubing hanger shall allow for ability for recut of or ability to re-establish the thread.

d. Tubing hanger design shall provide a method of protecting hydraulic lines and electrical through penetrations at the bottom of the tubing hanger. On vertical dual bore systems in wellhead, provision for protection may not be possible due to casing hanger interface, therefore protection prior to running shall be provided.

e. Tubing connection to the bottom of the hanger shall be designed to prevent the tubing from backing off.

f. Hydraulic and chemical injection couplers on the hanger shall prevent water ingress if disconnected and shall maintain pressure in the downhole lines. SCSSV line shall vent. Couplers on HXT systems may retain pressure when not mated to allow pre-charge of SCSSV valve for installation/circulation purposes.

g. The running profile shall be fully rated for the worst loading condition that may be encountered and shall include capacity for tubing weight, shut in pressure, and overpull.

h. All nipple profiles in the TH shall have positive landing shoulders.

Add New Subclause

9.2.1.1 Horizontal tree type tubing hanger

Orientation feature should allow the TH to be installed from any heading.

9.2.2 Loads

Add to 9.2.2

a. In a VXT system, with TH set in wellhead, the TH shall resist rotational torque of 47 500 Nm (35 000 ft-lbs). This is to accommodate built up torque when setting hanger, especially in deviated wells.

b. Supplier shall provide overpull capacity.

9.2.9 SCSSV and chemical-injection control-line stab design

Add to 9.2.9

a. On VXT, where a spring loaded relief valve is utilised on the SCSSV line it shall not maintain a pressure within the SCSSV circuit of more than 6,9 bar (100 psi) above ambient when vented to sea.

b. It shall be possible to lock open the SCSSV during installation of the TH.

9.2.10 Miscellaneous tools

Add New Subclause

9.2.10.1 HXT TH isolation sleeve

a. TH isolation sleeve shall provide isolation of the production outlet, to allow circulation of the production string during running/retrieval.

b. The following design requirements shall apply:

   1. TH isolation sleeve shall be locked in place.

   2. TH isolation sleeve rated working pressure shall be the same as the tree system rated working pressure.

Add New Subclause

9.2.10.2 HXT TH protection sleeve

a. During down hole operations, adequate protection of the TH internals, such as seal areas and landing/locking profiles, shall be provided by means of wire-line deployed protection sleeve.

b. These shall allow free passage of subsequent wire-line tool strings with smooth transitions to the bore. The protection sleeve shall be suspended and locked in the TH.

c. Protection sleeve shall be locked in place.

<u>Add after Annex O</u>

Annex P
Validation testing
(Informative)

P.1 Introduction

This section addresses clarifications and additions to API 17D validation testing and should be read concurrently with API 17D 5.1.7. The intent is to provide a preferred interpretation of API 17D validation testing requirements.

It is not expected or desired that these requirements drive re-validation but should be used for gap assessment of existing products validated as per API 17D second edition and for validation testing of new designs.

P.2 General

Pressure cycles, temperature cycles, and endurance cycles should be performed as specified in API 17D in a cumulative test using one product without changing any seals or components.

Grease, sealant, or lubricant should not be used to mask defects in sealing systems. Lubricants may be used to aid in the assembly and break-in period of the equipment.

In the event of failure during validation testing, continued testing should start from beginning of test procedure.

P.3 Temperature cycling tests

Objective evidence should not be utilised as an alternative to testing.

P.4 Life-cycle/endurance testing

P.4.1 General

All valves, seals, or other components whose operation may be affected by external hydrostatic pressure should be tested in a hyperbaric chamber. If a component does not fit in a hyperbaric chamber, the test may be performed in a suitable test fixture simulating hyperbaric pressure.

Validation testing should include accurate simulations of all expected loads and service conditions as much as practical. Source of these loads may be either from environmental effects or other interfacing equipment.

Except where explicitly stated in the following sections; validation should be performed in a cumulative test on one product without maintenance, or addition of lubricant or sealant, or changing of any seals or components, or disassembly for the duration of the testing.

Pressure and temperature stabilisation requirements should be as per API 6A F.1.10.

P.4.2 Seals

Primary seals exposed to well bore and associated secondary seals, either metal-to-metal or non-metallic, should be validated in accordance with API 17D Table 3 as “seals exposed to well bore in production”.

Validation should also follow the intent of the API 6A Annex F PR2 sequence as follows, this will satisfy the 200 pressure/load cycle tests and 3 temperature cycle tests of API 17D Table 3.

a. Before performing all testing described below, seal should undergo FAT including a gas test performed at room temperature. Test pressure is rated working pressure and hold period is 15 minutes.

b. 160 pressure cycles at room temperature, as per API 17D 5.1.7.4.

c. Gas test performed at room temperature. Test pressure is rated working pressure and hold period is 1 hour.

d. 20 pressure cycles, as per API 17D 5.1.7.4 except performed at maximum rated temperature.

e. Gas test performed at maximum rated temperature. Test pressure is rated working pressure and hold period is 1 hour.

f. 20 pressure cycles, as per API 17D 5.1.7.4 except performed at minimum rated temperature.

g. Gas test performed at minimum rated temperature. Test pressure is rated working pressure and hold period is 1 hour.

h. Temperature cycles per API 6A steps F.1.11.3 e) through F.1.11.3 o).

i. Gas test performed at room temperature. Test pressure and hold period is as per API 6A F.1.11.3 p).

j. Gas test performed at room temperature. Test pressure and hold period is as per API 6A F.1.11.3 q).

k. Seals that are exposed to external hydrostatic pressure should be validated with hyperbaric testing per API 17D Annex L.

Acceptance criteria for seals should be as per API 17D PSL 3G Section 5.4.6.2.3. Seals that are identical in function but different in size, shape, or configuration should be validated separately.

Bi-directional seals should follow the full test sequence from both directions if the seal in question will be exposed to pressure variations from both directions by design.

Unidirectional seals should be validated from the primary pressure direction. At the beginning and the end of the validation test, it should be proven that the seal relieves pressure from the reverse direction, if this function is required by the design.

P.4.3 Subsea valves

P.4.3.1 General

The following testing requirements should apply to all subsea valves, both manual and actuated, that are exposed to wellbore fluids.

All valve validation testing should be conducted on a single valve, without maintenance, or addition of lubricant or sealant, or replacement of any seals or components for the duration of the testing.

Valve should not be disassembled for any reason during testing.

Valve and hydraulic actuator assembly performance limits should be validated in accordance with criteria given in API 17D 7.10.4.1.3.

Pressure testing should be conducted in one direction only and should be performed in the expected direction of flow. This direction should be consistent throughout all testing, with the exception of final bidirectional low-pressure seat test for gate valves as specified in API 6A F.2.3.3.15 and FAT gas seat test as specified in API 17D 5.4.6.2.3.

As per API 17D Section 5.1.7.2 secondary stem seals require independent testing.

Valve validation testing should meet API 17D requirements as follows (see Table P.1):

a. Before performing all testing described below, valve should undergo FAT per API 17D 5.4.6.

b. PR2 sequence, as per API 6A F.2.3 for PR2 valves. This will satisfy 200 of the 600 endurance cycles and the 3 temperature cycles required by API 17D Table 3.

c. 200 hyperbaric cycles, as per API 17D Annex L and in accordance with the requirements of API 17D 7.10.4.1.3. This will satisfy the 200 pressure/load cycles and 200 of the 600 endurance cycles required by API 17D Table 3.

d. 200 endurance cycles, as per API 6A F.2.2.2.2 except the number of cycles should be 200. This will complete the 600 endurance cycles required by API 17D Table 3.

e. After performing all testing described above, valve should undergo a gas body and gas seat test per API 17D 5.4.6.2.2 and 5.4.6.2.3.

Acceptance criteria for all gas stages of validation should be as per API 17D PSL 3G Section 5.4.6.2.3.

The testing requirements described in P.4.3 will satisfy the validation requirements for valve seals including those of P.4.2.

P.4.3.2 Gate valves

Tree gate valves in production and crossover bores should be validated for Class II sandy service per API 6AV1.

P.4.3.3 Check valves

For check valves without any penetrations running through the body wall, 200 endurance cycles may be performed in lieu of the 200 hyperbaric cycles.

P.4.3.4 Needle valves

The validation testing of needle valves should be performed per the requirements of P.4.3.1; there are no additional validation requirements.

P.4.4 Subsea valve actuators

P.4.4.1 General

The following general requirements should apply to valve actuators, both hydraulic and manual.

Actuator should be installed on corresponding valve for validation testing and may be validated concurrent with valve validation testing.

When size restrictions prevent hyperbaric validation testing of the valve and actuator simultaneously, the actuator should be coupled with a dummy valve that replicates the valve functional loading for all hyperbaric validation test conditions.

Valve actuators validation testing should meet API 17D requirements as follows (see Table P.1):

a. PR2 sequence, as per API 6A F.2.5 for PR2 actuators. This will satisfy 200 of the 600 endurance cycles and the 3 temperature cycles required by API 17D Table 3.

b. 200 hyperbaric cycles, as per API 17D Annex L. This will satisfy the 200 pressure/load cycles and 200 of the 600 endurance cycles required by API 17D Table 3.

c. 200 endurance cycles, as per API 6A F.2.5.b except the number of cycles should be 200. This will complete the 600 endurance cycles required by API 17D Table 3.

Valve position indicator should be verified such that indicator shows true position of valve flow path.

P.4.4.2 Hydraulic valve actuators

No seal replacement, actuator redress, or disassembly should be allowed during testing.

Before and after completion of testing in P.4.4.1, actuator should undergo FAT including hydrotest at 20 percent and 100 percent of the RWP of the actuator, as described in API 17D 7.10.4.2.3 item c).

P.4.4.3 Valve actuators with ROV linear override

Force required and linear travel to fully stroke and override the valve (determined with calculations and confirmed during testing) should be measured and recorded before and after completion of testing in P.4.4.1.

Force measurement should be conducted under atmospheric conditions and the following recorded:

a. Operating force required to stroke the valve from its failed position (i.e. compress the spring) with zero pressure in bore.

b. Operating force required to fully open a fail-closed valve with maximum pressure differential, which is RWP, across the gate.

c. Operating force required to fully close a fail-open valve with rated working pressure in the valve bore and body.

d. Maximum operating force (determined with calculations) that can be applied to ROV interface in fully stroked position without damage or deformation to any valve component that would impair or affect performance.

P.4.4.4 Valve actuators with ROV rotary override

Torque required, number of turns, and direction of rotation to operate should be measured and recorded before and after completion of testing in P.4.4.1.

Measurement should be conducted under atmospheric conditions as follows:

a. Operating torque required to stroke valve fully open and closed with zero pressure in bore.

b. Operating torque required to stroke valve fully open, starting from closed position with maximum pressure differential across gate.

c. Maximum operating torque—maximum torque (determined with calculations and confirmed during testing) that can be applied in full open and full closed positions without damage or deformation to any valve component that would impair or affect performance.

d. Performance of open/close indicator should be validated against valve pressure signature.

e. Number of turns and direction to override valve should be recorded.

Measurement should be conducted at maximum rated water depth conditions (hyperbaric chamber testing) as follows:

a. Operating torque required to stroke valve fully open and closed with zero pressure in the bore.

b. Operating torque required to stroke valve fully open, starting from closed position with RWP differential across gate.

c. Performance of open/close indicator should be validated against valve pressure signature.

d. Number of turns and direction to override valve should be recorded.

P.4.4.5 Manual valve actuators

Torque required, number of turns, and direction of rotation to operate should be measured and recorded before and after completion of testing in P.4.4.1.

Measurement should be conducted under atmospheric conditions as follows:

a. Operating torque required to stroke valve fully open and closed with zero pressure in bore.

b. Operating torque required to stroke valve fully open, starting from closed position with RWP differential across gate and operating torque required to stroke valve fully closed from open position with RWP within the valve bore and body.

c. Number of turns and direction to override valve should be recorded.

d. Maximum operating torque—maximum torque (determined with calculations) that can be applied in full open and full closed positions without damage or deformation to any valve component that would impair or affect performance.

e. Performance of open/close indicator should be validated against valve pressure signature.

f. Number of turns and direction to override valve should be recorded.

Measurement should be conducted at maximum rated water depth conditions (hyperbaric chamber testing) as follows:

a. Operating torque required to stroke valve fully open and closed with zero pressure in the bore.

b. Operating torque required to stroke valve fully open, starting from closed position with maximum pressure differential across gate and operating torque required to stroke valve fully closed from open position with RWP within the valve bore and body.

c. Performance of open/close indicator should be validated against valve pressure signature.

d. Number of turns and direction to override valve should be recorded.

P.4.5 Tubing hanger annulus isolation device (annulus isolation valve)

Annulus isolation valve validation testing should meet API 17D requirements as follows:

a. Before performing all testing described below, valve should undergo FAT including a gas body and gas seat test per API 17D 5.4.6.2.2 and 5.4.6.2.3.

b. Modified PR2 sequence with no dynamic cycles at maximum or minimum temperature; as per intent of API 6A F.2.3 for PR2 valves and modifications below, this will satisfy 200 pressure/load cycles, 200 endurance cycles and 3 temperature cycles required by API 17D Table 3 and 5.1.7.6.

    1. API 6A F.2.3.3.1 Force or torque measurement: should be conducted twice, once with pressure differential from below and once from above.
    2. API 6A F.2.3.3.2 Dynamic test at room temperature: number of cycles should be 200 with 100 cycles performed with pressure differential from below and 100 cycles performed with pressure differential from above.
    3. API 6A F.2.3.3.3 Dynamic test at maximum rated temperature: should not be performed.
    4. API 6A F.2.3.3.4 Gas body test at maximum rated temperature: should be performed with pressure differential from both above and below and at room temperature.
    5. API 6A F.2.3.3.5 Gas seat test at maximum rated temperature: should be performed with pressure differential from both above and below and at room temperature.
    6. API 6A F.2.3.3.6 Low-pressure seat test at maximum rated temperature: should be performed with pressure differential from both above and below and at room temperature.
    7. API 6A F.2.3.3.7 through F.2.3.3.10: should not be performed.

8. API 6A F.2.3.3.11 Body pressure/temperature cycles: Perform steps F.1.11.3 a) through F.1.11.3 o).
9. API 6A F.2.3.3.12 Body pressure holding test at room temperature: should be performed.
10. API 6A F.2.3.3.13 Gas seat test at room temperature: should be performed with pressure differential from both above and below.
11. API 6A F.2.3.3.14 Body low-pressure holding test: should be performed.
12. API 6A F.2.3.3.15 Low-pressure seat test at room temperature: should be performed with pressure differential from both above and below.
13. API 6A F.2.3.3.16 Final force or torque measurement: should be conducted twice, once with pressure differential from below and once from above.

c. Hyperbaric testing per API 17D Annex L.

P.4.6 Chokes

All choke valve validation testing should be conducted on same valve, without maintenance, addition of lubricant or sealant, or replacement of any seals or components for the duration of the testing.

Choke valve should not be disassembled for any reason during testing.

Choke valve validation testing should meet API 17D requirements as follows (see Table P.2):

a. Before performing all testing described below, choke valve should undergo FAT including gas body test per API 17D 5.4.6.2.2.

b. PR2 sequence, as per API 6A F.2.7 for PR2 chokes. This will satisfy 200 of the 500 endurance cycles and the 3 temperature cycles required by API 17D Table 3.

c. 200 hyperbaric cycles, as per API 17D Annex L. This will satisfy the 200 pressure/load cycles and 200 of the 500 endurance cycles required by API 17D Table 3.

d. 100 endurance cycles as per API 6A F.2.7.4 except the number of cycles should be 100. This will complete the 500 endurance cycles required by API 17D Table 3.

e. After performing all testing described above, choke valve should undergo gas body test per API 17D 5.4.6.2.2.

P.4.7 Choke actuators

Actuator should be installed on corresponding choke for validation testing and may be validated concurrent with choke validation testing.

Choke actuator seals should be tested in accordance with API 17D. Choke position indicator should be verified for accurate position reading. Both mechanical and electrical (if applicable) indicator function(s) should be verified.

As used in the following clauses the term ‘endurance cycle’ follows the definition for PR2 actuators (open-close-open) and ‘choke actuator endurance cycle’ follows the definition of API 17D Table 3 Note e) (full-open to full-close or full-close to full-open).

Choke actuator validation testing should meet API 17D requirements as follows (see Table P.3):

a. Before performing all testing described below, actuator should undergo FAT including hydrotest at 20 percent and 100 percent of the RWP of the actuator, as described in API 17D 7.21.4.2.2.

b. PR2 sequence, as per API 6A F.2.5 for PR2 actuators. This will satisfy 400 of the 1 000 choke actuator endurance cycles and the 3 temperature cycles required by API 17D Table 3.

c. 200 hyperbaric cycles, as per API 17D Annex L. This will satisfy the 200 pressure/load cycles and 400 of the 1 000 choke actuator endurance cycles required by API 17D Table 3.

d. 100 endurance cycles as per API 6A F.2.5.b except the number of cycles should be 100. This will satisfy 200 of the 1 000 choke actuator endurance cycles required by API 17D Table 3.

e. Further endurance cycles as per API 6A F.2.5.b except the number of cycles should be performed to reach a cumulative 1 million actuator steps.

f. After performing all testing described above, actuator should undergo FAT including hydrotest at 20 percent and 100 percent of the RWP of the actuator, as described in API 17D 7.21.4.2.2.

P.5 Product family validation

Validation of product family by API 17D scaling methods should not be used to meet equipment validation testing requirements except for sand slurry test if the valves are members of a product family, as defined in API 6AV1, and have the same geometric shape at the body cavity, gate, seat, and seals.

P.6 Documentation

All validation test records should be continuous for both pressure and temperature tests (that is, no breaks in the recording/logging of any of the test data).

Validation testing documentation should include the following:

a. Validation test procedure.

b. Test charts.

c. Photographs and/or video of testing/equipment.

d. Signatures of testing technician(s) and witness(s).

e. Assembly and component traceability (assembly number, part numbers, revisions, serial numbers, material, weld nondestructive examination, etc.).

f. General assembly drawings of all equipment, including test equipment.

g. Stackup drawing of test setup.

h. Validation testing report.

i. Dimensional report of all critical parts before and after testing.

Table P.1 – Interpretation of API 17D Table 3 cycles for valves and valve actuators

API 17D Table 3 requirement for valves and actuators		Pressure/load cycling test	Temperature cycling test	Endurance cycling test (total cumulative cycles)
		200	**3**	**600**
	to be satisfied by:			
Gate valves Needle valves	**Validation test**	API 6A F.2.3 Design validation for PR2 valves 200 cycles + 3 temperature cycles	API 17D Annex L Hyperbaric testing 200 cycles	API 6A F.2.2.2.2.1 Modified endurance cycling test 200 cycles
	Number of API 17D Table 3 cycles accumulated for each test	200 endurance cycles 3 temperature cycles	200 endurance cycles 200 pressure/load cycles	200 endurance cycles
Check valves	**Validation test**	API 6A F.2.3 Design validation for PR2 valves 200 cycles + 3 temperature cycles	API 17D Annex L Hyperbaric testing 200 cycles OR (if design is not affected by hyperbaric pressure) API 6A F.2.2.2.2.2 Modified endurance cycling test 200 cycles	API 6A F.2.2.2.2.2 Modified endurance cycling test 200 cycles
	Number of API 17D Table 3 cycles accumulated for each test	200 endurance cycles 3 temperature cycles	200 endurance cycles 200 pressure/load cycles	200 endurance cycles
Valve actuators	**Validation test**	API 6A F.2.5 Design validation for PR2 actuators 200 cycles + 3 temperature cycles	API 17D Annex L Hyperbaric testing 200 cycles	API 6A F.2.5 b) Modified endurance cycling test 200 cycles
	Number of API 17D Table 3 cycles accumulated for each test	200 endurance cycles 3 temperature cycles	200 endurance cycles 200 pressure/load cycles	200 endurance cycles

Table P.2 – Interpretation of API 17D Table 3 cycles for choke valves

API 17D Table 3 requirement for choke valves		Pressure/load cycling test	Temperature cycling test	Endurance cycling test (total cumulative cycles)
		200	**3**	**500**
to be satisfied by:				
Choke valves	**Validation test**	API 6A F.2.7 Design validation for PR2 chokes 200 cycles + 3 temperature cycles	API 17D Annex L Hyperbaric testing 200 cycles	API 6A F.2.7.4 Modified endurance cycling test 100 cycles
	Number of API 17D Table 3 cycles accumulated for each test	200 endurance cycles 3 temperature cycles	200 endurance cycles 200 pressure/load cycles	100 endurance cycles

Table P.3 – Interpretation of API 17D Table 3 cycles for choke valve actuators

<table>
<tr><th colspan="2" rowspan="2">API 17D Table 3 requirement for choke valve actuators</th><th>Pressure/load cycling test</th><th>Temperature cycling test</th><th>Endurance cycling test
(total cumulative cycles)</th></tr>
<tr><th>200</th><th>3</th><th>1000
(choke actuator endurance cycles)</th></tr>
<tr><td colspan="5">to be satisfied by:</td></tr>
<tr><td rowspan="3">Choke valve actuators</td><td>Validation test</td><td>API 6A F.2.5
Design validation for PR2 actuators
200 cycles + 3 temperature cycles</td><td>API 17D Annex L
Hyperbaric testing
200 cycles</td><td>API 6A F.2.5.b
Modified endurance cycling test
100 cycles</td></tr>
<tr><td>Number of API 17D Table 3 cycles accumulated for each test</td><td>400 choke actuator endurance cycles
3 temperature cycles</td><td>400 choke actuator endurance cycles
200 pressure/load cycles</td><td>200 choke actuator endurance cycles</td></tr>
<tr><td>Additional testing</td><td colspan="3">Further endurance cycles as per API 6A F.2.5.b except the number of cycles should be performed to reach a cumulative 1 million actuator steps</td></tr>
</table>