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Functional Design and Test Requirements for an Optical Feedthrough System used in Subsea Xmas Tree Installations

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Contents

Foreword

This guidance note has been prepared under the auspices of the Subsea Fiber Optic Monitoring (SEAFOM) joint industry group, and the Feedthrough System Working Group, formed to promote international standardization of subsea optical monitoring and sensing functional and test parameters for optical feedthrough systems used in subsea Christmas Trees (XT). This document specifically addresses the interface between the subsea environment of the XT and the downhole or reservoir environment for transmission of optical data through the XT.

This guidance note outlines the minimum design and functional requirements, and the minimum qualification and factory acceptance test requirements for an optical feedthrough system (OFS) to be used in intelligent well applications using vertical or horizontal subsea Christmas (Xmas) Trees. The XT forms the critical pressure containment barrier between the well and the subsea environments, and as such, all interfaces within the XT shall meet the requirements of the XT as a barrier system as defined within API 6A / ISO 10423, API 17D / ISO 13628-4 and ISO 13628-6/API 17 F.

1 Introduction

This recommended practice outlines the minimum design and functional requirements, as well as the minimum qualification and factory acceptance test requirements for an optical feedthrough system (OFS) to be used in intelligent well applications through vertical or horizontal subsea Christmas (Xmas) Trees (XT). The primary function of the OFS is to provide optical communication between permanently installed downhole instrumentation (sensors, gauges) and a surface or subsea located control systems while providing full pressure-containment through the XT as required by ISO 10423 (API 6A) and ISO 13628-4 (API 17D). The OFS consists of one or more wetmateable, drymateable optical connectors or penetrators interconnected as needed to establish and maintain optical communication and pressure-containment through the various XT system components. Interface details between the connector elements and the end user's equipment are outside the scope of this specification. However, the connectors and interfaces must be suitable for the conditions described within this specification.

Although this specification is primarily written to address qualification and factory acceptance testing of optical systems, there may be systems comprised of optical and electrical elements requiring testing. Such system designs are referred to as "hybrid". In such cases, this specification addresses the optical performance and test parameters, and the electrical performance and test parameters are addressed in IWIS-RP-A1, ISO 13628-6 or a client specification.

The SEAFOM and IWIS specifications are largely complimentary documents in that most of the physical tests are similar, with the primary differences being the testing related to optical or electrical performance characteristics.

The tests described within this document are "designed" to replicate and/or exceed the environments that the feedthrough systems may experience in order to ensure that the product is suitably qualified for service once the test program is satisfactorily completed.

1.1 Documentation

Documentation may include the following as a minimum, but the contract shall identify the deliverable documentation as required by the client/operator:

- Project Interface Datasheet – identification of all client-driven requirements beyond the scope of this document
- Performance Verification Test (PVT) report (for new supplier or application qualification)
- Factory Acceptance Test (FAT) report
- Handling, shipping and storage procedures
- Product data sheets defining pertinent OFS parameters
- Procedures documenting safe installation, test and deployment of the OFS

1.2 Critical Interfaces

1.2.1 External Interfaces

The connector and/or penetrator design and qualification shall take into account all external interfaces such as the downhole cable and subsea jumper. These external interfaces are to be clearly specified in the design documentation as well as in project specific application requirements defined by the client. Refer to the Project Interface Datasheet at the end of this guidance note.

1.2.2 Internal Interfaces

The connector and/or penetrator design comprising the feedthrough system is required to fit into the machined preparations defined by the Xmas Tree vendor for the XT, Tubing Hanger, Tubing Hanger Running Tool, or other internal interfaces as specified by the Xmas Tree vendor.

1.2.3 Welding

When welding is to be used in a design, the manufacturer is to use only current, approved weld procedure specifications (WPS) and weld procedure qualification records (WPQR). Any unqualified welding shall be qualified in accordance with the governing specifications and the client/operator requirements which are outside the scope of this document.

Precautions shall be made to not create any damage of any portion of the optical feedthrough system attributed to post-installation welding.

1.2.4 Service Classes

There are various classes for pressure and temperature ratings for working (operating) levels:

Class A: 69MPa/121C (10k/250F) - Wellhead internal pressure and temperature service rating of 0 to 69MPa (Pw) (0 to 10,000psig) and -18° to121°C (TT) (0° to 250°F) (this coincides with ISO 10423 (API 6A) U Class temperature rating), as well as external seawater hydrostatic working pressure (Pw) of 34.5MPa (5,000psig) maximum. The deployment water depth is 0 to 3,048m (0 to 10,000ft).

Class B: 103MPa/150C (15k/302F) - Wellhead internal pressure and temperature service rating of 0 to 103MPa (Pw) (0 to 15,000psig) and -18° to150°C (TT) (0° to 302°F) and external seawater hydrostatic working pressure (Pw) of 45.5MPa (6,600psig) maximum. The deployment water depth is 0 to 4,572m (0 to 15,000ft).

Class C: 69MPa/177C (10k/350F) - Wellhead internal pressure and temperature service rating of 0 to 69MPa (Pw) (0 to 10,000psig) and -18° to177°C (TT) (0° to 350°F) (this coincides with ISO 10423 (API 6A) X Class temperature rating) and external seawater hydrostatic working pressure of (Pw) 34.5MPa (5,000psig) maximum. The deployment water depth is 0 to 3,048m (0 to 10,000ft).

Class D: 103MPa/177C (15k/350F) - Wellhead internal pressure and temperature service rating of 0 to 103MPa (Pw) (0 to 15,000psig) and -18° to177°C (TT) (0° to 350°F) (this coincides with ISO 10423 (API 6A) X Class temperature rating) and external seawater hydrostatic working pressure (Pw) of 45.5MPa (6,600psig) maximum. The deployment water depth is 0 to 4,572m (0 to 15,000ft).

Class E: 138MPa/177C (20k/350F) - Wellhead internal pressure and temperature service rating of 0 to 138MPa (Pw) (0 to 20,000psig) and -18° to177°C (TT) (0° to 350°F) (this coincides with ISO 10423 (API 6A) X Class temperature rating) and external seawater hydrostatic working pressure (Pw) of 45.5MPa (6,600psig) maximum. The deployment water depth is 0 to 4,572m (0 to 15,000ft).

2 Scope

This specification outlines the minimum design and functional requirements, and the minimum qualification and factory acceptance test requirements for an optical feedthrough system (OFS) to be used in intelligent well applications using vertical or horizontal subsea Christmas (Xmas) Trees (wellhead system).

3 Safety Statements

3.1 WARNINGS

- LASER safety: Fiber optic test and operational equipment can include LASER sources of high power and infrared (invisible) energy. This energy can cause permanent eye damage to personnel either working with such equipment or working in the same area. Appropriate measures must be taken to prevent any eye damage from occurring. Appropriate eye protection glasses shall be worn by personnel working on, or in close proximity to optical testing. Further definitions for LASER safety can be found in IEC 60825 and ANSI Z136.1
- Proper protective equipment and handling procedures shall be used when working with fiber to eliminate direct or indirect hazards to all personnel in the area. As a minimum, safety glasses with side shields are required.
- Proper cautionary signs of potentially hazardous testing in progress must be highly visible and test areas shall be roped off or suitably delineated.
- The testing required herein and those deemed necessary by the contractor will be performed in a safe and secure test area within the test facility. Only trained test personnel will perform testing, and witnesses shall only be allowed to enter the area when test parameters are stabilized.
- The test area must not be left unattended under any circumstances while the test equipment or UUT is being pressurized.
- Extreme caution must be taken when lifting heavy items.
- Additional personal protective equipment as appropriate should be used at all times.
- In the event that fusion splicing is necessary on a rig (onshore or offshore), or in any potentially explosive environment, proper hot work permits and approvals must be obtained from site HSE managers.

3.2 CAUTIONS

- Caution must be exercised during assembly and testing to ensure that all fittings, hydraulic and gas equipment are correctly rated and properly installed for the test.
- Provisions shall be made to include a system pressure-relieving / controlling device to ensure that any test surge pressures are in accordance with ISO 13628-4/API 6 A.
- Should there be any doubt about the intent of the governing requirements at any time during testing, stop testing immediately, make test equipment safe and contact the design authority.
- Safety shall be everyone’s concern and responsibility.

4 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

General Terms:

4.1 Alignment

Specific to stab-mate engagement interface and the mechanical and physical orientation between mating halves of a connector pair, typically the wet-mate connector.

4.2 Axial Alignment

Alignment between connector halves along the centerline of the connector related to end-face position (longitudinal tolerance, d) with coincident centerlines.

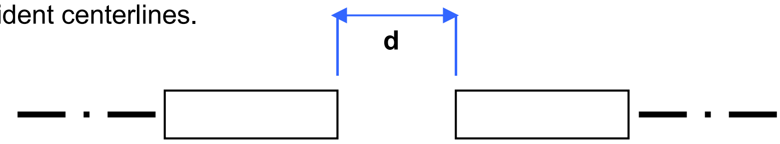

Figure 1: Axial Alignment

4.3 Angular Alignment

Angular alignment (Θ) between connector halves of the angle formed between the centerline of one half of the connector respective to the centerline of the mating half of the connector (angular tolerance).

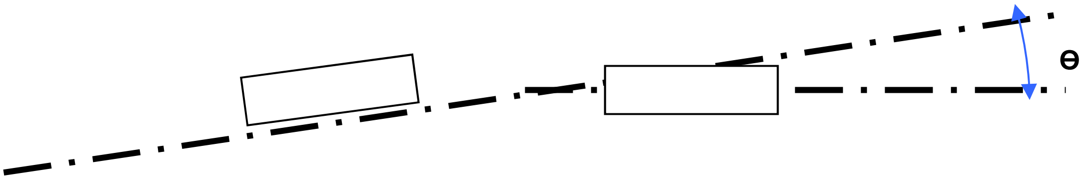

Figure 2: Angular Alignment

4.4 Radial Alignment

Alignment between connector halves associated with offset (e) in a direction perpendicular to the centerline of one half of the connector relative to the centerline of the mating half of the connector (radial tolerance).

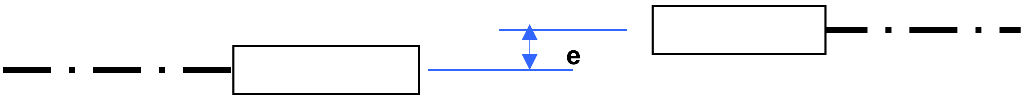

Figure 3: Radial Alignment

4.5 Rotational Alignment

Angular alignment (Ω) between connector halves related to primary keying orientation.

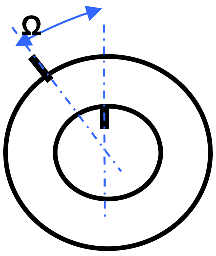

Figure 4: Rotational Alignment

4.6 Annulus

The space formed between the production pipe and the casing or bore hole.

4.7 Barrier

Structural and pressure-containment capability consisting of one or more sealing mechanisms at every pressure boundary:

Internal pressure barrier is located in the Annulus and Gallery (i.e. within the well and Xtree).
External pressure barrier is located outside the Xmas Tree on the subsea side.

4.8 Class

Service rating designation defining maximum working pressure and temperature limits of equipment, as defined in table 1, Section 8.

4.9 Completion Fluid

A solids-free, dense liquid composition used to “complete” an oil or gas well. The fluid is used to control the well during completions and workover activities without damaging the reservoir formation or completion components. Completion fluids are typically brines (chlorides, bromides and formates).

4.10 Connector

Electric, fiber optic, hydraulic device or combination consisting of two mating halves, one referred to as the female (socket or plug) half and the other the male (pin or receptacle) half, which upon engaging completes the transmission circuit through the device. Convention calls for the plug to be engaged into the receptacle.

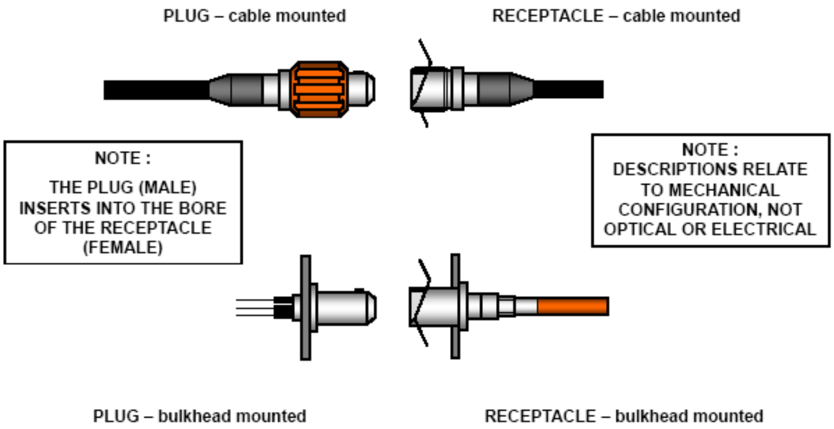

Figure 5: Connector

4.11 Corrosion Inhibitor

A chemical additive used in acid treatments to protect iron and steel components in the wellbore and treating equipment from the corrosive treating fluid. Corrosion inhibitors generally are mixed with the treatment fluid and are formulated to be effective in protecting the metal components the fluid is likely to contact.

4.12 Downhole

That portion of a drilled and completed well within the wellbore (borehole) located below the subsea wellhead, including the Annulus.

4.13 DHG

Downhole Gauge.

4.14 Drymate

A connector with an interface capable of being engaged and disengaged many times in an ambient atmospheric environment, typically not tolerant of wetmating or being engaged in wet or moist environments.

4.15 Dual Barrier

Pressure-containment: Consisting of two independent (dissimilar) seal mechanisms at every pressure boundary with a primary and secondary seal.

4.16 FAT

Factory Acceptance Test; production-type test

4.17 Gallery

The space formed between the tubing hanger and the tree valve block above the TH middle pack-off seal.

4.18 Interface Datasheet

A document that allows customers and their clients to define project specific requirements or a given sensor system for integration into the system infrastructure (e.g. XT, subsea interfaces, downhole interfaces, cables, control lines, etc.), sensor functional parameters and requirements (e.g. test methods, test wavelengths, etc.), reservoir and completion media composition, etc.

4.19 OFS

Optical Feedthrough System

4.20 Open and Reverse Face

Open is the engaging (front) or mating interface of a connector pair and reverse is the non-engaging (back) half of the connector pair.

Optical Terms:

4.21 Attenuation

The decrease in signal strength along an optical fiber (waveguide) caused by absorption and scattering. Attenuation is normally expressed in decibels per kilometer (dB/km).

4.22 Backreflection

In cases where light is launched into an optical fiber (waveguide), backreflection refers to the light (power) that is returned to the launch point or source.

4.23 C & L Bands

Spectral band designations for transmission wavelength ranges as defined by International Telecommunications Union in accordance with ITU-T SG15 per below table.

Band	Descriptor	Wavelength Range (nm)
O band	Original	1260 to 1360
E band	Extended	1360 to 1460
S band	Short Wavelength	1460 to 1530
C band	Conventional	1530 to 1565
L band	Long Wavelength	1565 to 1625
U band	Ultralong Wavelength	1625 to 1675

4.24 Insertion Loss (IL)

The loss of transmitted power resulting from inserting a component, such as a connector or splice, into a previously continuous, uninterrupted path of fiber. IL is normally expressed in dB.

4.25 Power Budget

The maximum optical loss of the overall system, including all active and passive devices within the system – connectors, splices, cable (attenuation, macro bending and micro bending losses), attenuators, isolators, switches, couplers, sensors, etc., with which the system can operate within its specified performance range.

4.26 Multi Mode (MM)

An optical fiber that has a core large enough to carry and propagate more than one mode (electromagnetic wave) of light. The typical core diameter is 50 to 62.5μm.

4.27 Return Loss (RL)

Optical return loss (ORL) is the ratio of optical power reflected by a component or an assembly to the optical power incident on a component port when that component or assembly is introduced into a link or system. RL is normally expressed in dB.

4.28 Single Mode (SM)

An optical fiber that has a core small enough to carry and propagate only one mode of light (consisting of two orthogonal polarization states of the transverse electromagnetic wave). The typical core diameter is 8.0 to 10.0μm. Also referred to as monomode.

4.29 Splice (Fusion)

A permanent joint formed between two fibers by fusing the core/cladding together using a focused electrical discharge pulse.

4.30 Oxygen Scavenger

A chemical that reacts with dissolved oxygen (O_2) to reduce corrosion, such as sulfite (SO_3) and bisulfite (HSO_3) ions that combines with oxygen to form sulfate (SO_4).

4.31 Penetrator/Feedthrough

A transmission device (electrical, optical, hydraulic or combination) inserted through a pressure vessel maintaining full pressure containment integrity of the pressure vessel.

4.32 P_T Pressure, test (maximum); 1.5 x working pressure (Pw) of the XT:

Internal pressure is located in the Annulus, Production Tube and Gallery (i.e. within the well and Xtree).

External pressure is located outside the Xmas Tree on the seawater side.

4.33 Pw Pressure, working (maximum) of the XT:

Internal pressure is located in the Annulus, Production Tube and Gallery (i.e. within the well and Xtree).

External pressure is located outside the Xmas Tree on the seawater side.

4.34 PVT

Performance Verification Testing; also referred to as qualification testing or type testing.

4.35 Redundant Sealing

More than one pressure–retaining seal mechanism of a similar design.

4.36 Scoop Proof

A mechanical configuration that prevents damage during connector mating to the contact elements of the two halves by assuring proper alignment and orientation prior to internal contact engagement.

4.37 T_T

Temperature, test (range) [also working temperature range]

4.38 TEC

Tubing Encapsulated Cable

4.39 Test Connector

Can consist of actual production connector halves, prototypes or individual test dummies to facilitate testing of individual components.

4.40 UUT

Unit Under Test – synonymous with the term DUT, or Device Under Test.

4.41 Wet-mate

A connector with an interface capable of being engaged and disengaged many times by manual or remote means in ambient seawater and/or wellhead environments; also capable of being drymated.

4.42 Wellhead (Subsea)

A pressure containing housing located at the mudline that provides a means for suspending and sealing the well casing strings, and supporting and sealing the subsea completion stack and XT. It is common to use the term wellhead interchangeably with XT, but they are distinctly different pieces of equipment with different functions.

4.43 Wellhead Outlet (WHO)

A component which is mechanically attached and sealed to the external surface of the Xmas Tree to form a barrier and permit the passage of electrical, optical, hydraulic transmission or a combination thereof (see Connector, Feedthrough or Penetrator). To distinguish between a XTFS, the WHO is readily accessible, made up and serviced on the surface

4.44 Xmas Tree (XT)

A subsea structure consisting of valves and actuators landed remotely on a casing or wellhead through which a well is controlled and produced. A Horizontal Xmas Tree is designed to land on the wellhead and suspend the tubing hanger within the tree body and divert the production flow out horizontally. A Vertical Xmas Tree is designed to land on top of the tubing hanger installed into the wellhead and divert the production flow out vertically.

4.45 XTFS

Xmas Tree Feedthrough System – generic term for a Xmas Tree feedthrough system whether it is electrical, optical or hybrid (electrical and optical). To distinguish between a WHO, the XTFO is strictly used on subsea XT's and are not accessible.

5 System Configuration

5.1 Horizontal Xtree Feedthrough System (HXTFS) Generic Configuration

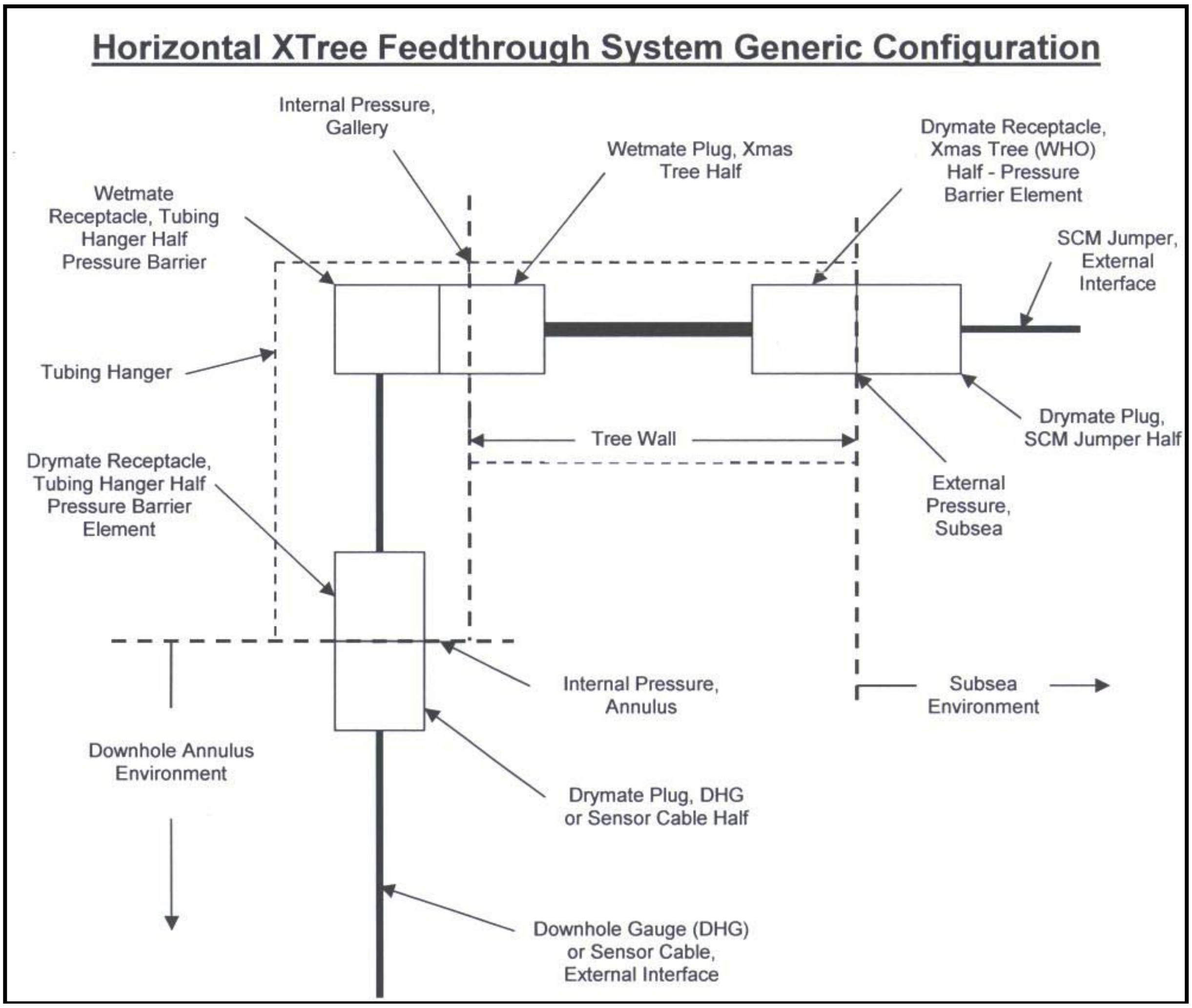

Figure 6:
The above schematic is representative of a horizontal Xtree feedthrough system configuration. Alternate configurations including some but not all components illustrated may be utilized.

5.2 Vertical Xtree Feedthrough System (VXTFS) Generic Configuration

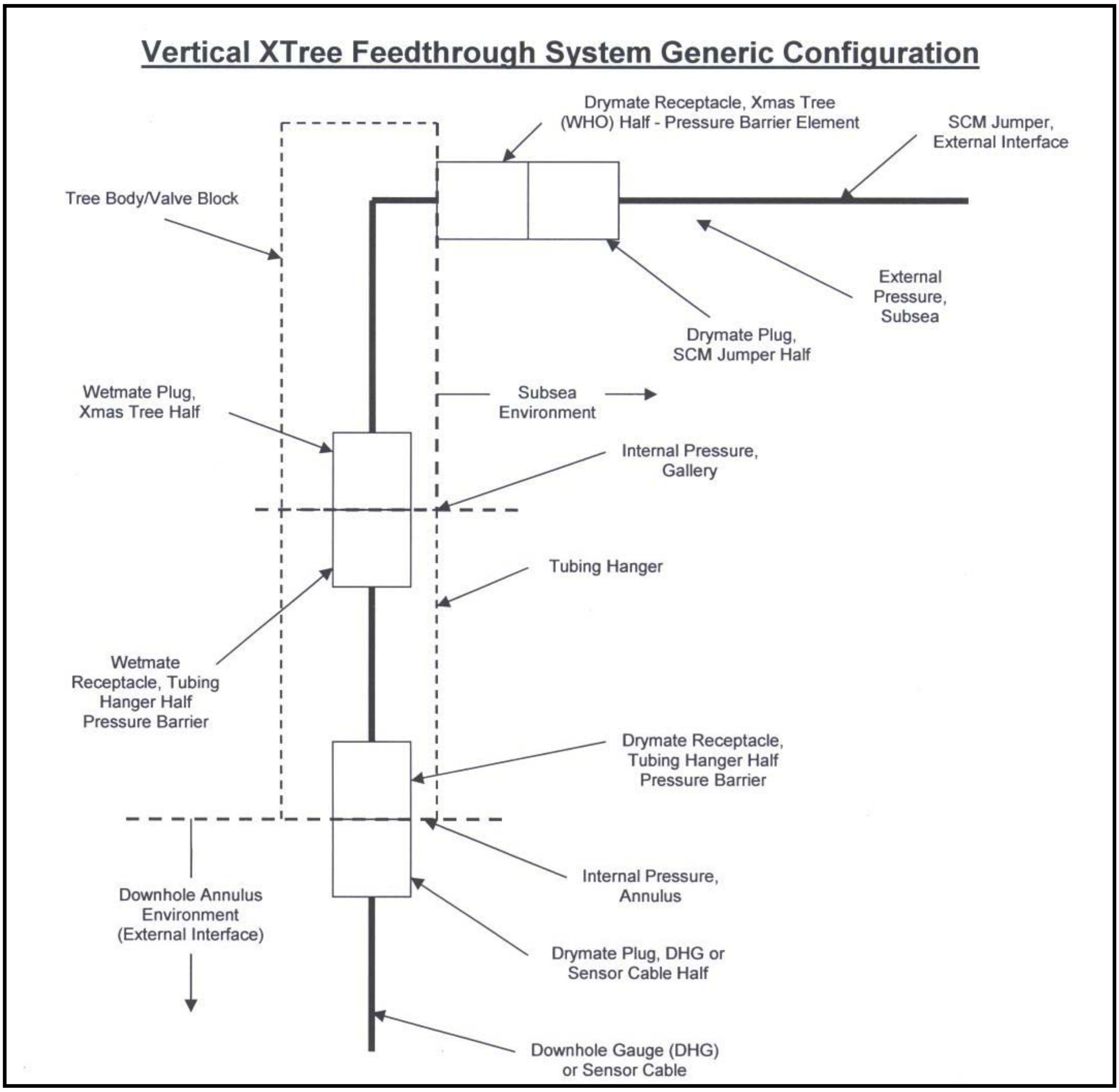

Figure 7:
The above schematic is representative of a vertical Xtree feedthrough system configuration. Alternate configurations including some but not all components illustrated may be utilized.

6 Reliability

Reliability of the connector / penetrator system is critical. The design shall take into consideration all aspects of the operations involved with delivery, storage, installation and use of the system and components. Of particular importance is the installation of offshore components. The design objective shall result in as simple and robust a design as possible minimizing the possibility of premature failure.

Due consideration shall be given to Failure Mode Effects and Criticality Analysis (FMECA) during the design process.

7 Service Conditions

Design in accordance with latest revisions of the following:

- ISO 10423 / API 6A - PSL3, PSL3G (as specified by contract) and PR2
- ISO 13628-4 / API 17D
- ISO 15156 / NACE-MR0175
- ISO 13628-6

Table 1: Service and Test Conditions

Service Condition	Class A 69MPa/121C (10k/250F)	Class B 103MPa/150C (15k/302F)	Class C 69MPa/177C (10k/350F)	Class D 103MPa/177C (15k/350F)	Class E 138MPa/177C (20k/350F)
Temperature range (TT)	-18° to 121°C (0° to 250°F)	-18° to 150°C (0° to 302°F)	-18° to 177°C (0° to 350°F)	-18° to 177°C (0° to 350°F)	-18° to 177°C (0° to 350°F)
Working pressure (Pw) internal	0 to 69MPa (0 to 10,000psig)	0 to 103MPa (0 to 15,000psig)	0 to 69MPa (0 to 10,000psig)	0 to 103MPa (0 to 15,000psig)	0 to 138 MPa (0 to 20,000psig)
Test pressure, internal (PT = 1.5x Pw)	0 to 103MPa (0 to 15,000psig)	0 to 155MPa (0 to 22,500psig)	0 to 103MPa (0 to 15,000psig)	0 to 155MPa (0 to 22,500psig)	0 to 207MPa (0 to 30,000psig)
Working pressure (Pw) external	0 to 34.5MPa (0 to 5,000psig)	0 to 45.5MPa (0 to 6,600psig)	0 to 34.5MPa (0 to 5,000psig)	0 to 45.5MPa (0 to 6,600psig)	0 to 45.5MPa (0 to 6,600psig)
Test pressure, external (PT = 1.5x Pw)	0 to 52MPa (0 to 7,500psig)	0 to 68MPa (0 to 9,900psig)	0 to 52MPa (0 to 7,500psig)	0 to 68MPa (0 to 9,900psig)	0 to 68MPa (0 to 9,900psig)
Deployment water depth	0 to 3,048m (0 to 10,000ft)	0 to 4,572m (0 to 15,000ft)	0 to 3,048m (0 to 10,000ft)	0 to 4,572m (0 to 15,000ft)	0 to 4,572m (0 to 15,000ft)

Design for a service life of 25 years.

Wet-mate connector halves remaining unmated and exposed to the ambient environment (surface or subsea) shall be capable of remaining unmated for a period of 12 months minimum. Intervention of the wet-mate connector half may be required to remove accumulated and settled debris and silt prior to wet-mate engagement.

Storage temperature range: -40° to 70°C (-40° to 158°F).

Materials testing will be performed if necessary per client specification as identified on the Project Interface Datasheet found in Appendix A.

Chemical exposure: suitable for ISO 10423 material class HH.
Typical chemical exposures are identified below, but exposures are not limited to this list and actual chemical exposures and test / validation methods shall be client-driven (using the Project Interface Datasheet found in Appendix A).

Seawater, hydrocarbon production fluids, diesel, mineral oil-based, synthetic and water-based control fluid, glycol/MEG, calcium bromide, calcium chloride, cesium formate, hydrogen sulfide, carbon dioxide, methanol, zinc bromide, silicone oil, oxygen scavengers, corrosion inhibitors, citric acid, acetic acid, and selected dielectric fluid (oil, gel, grease or similar used in design).

NOTE: It is sufficient for the manufacturer to demonstrate compatibility by prior experience or by additional testing as agreed to with the client.

8 Mechanical Performance Requirements

Maximum allowable mate / demate force for horizontal wet-mate connector actuation: 112 lbf (500 N)

Minimum mate / demate cycle life: 25 mates in turbid sand, salt and water medium (as defined in step 10.4).

Connector shear load resistance (Horizontal Tree): Maximum 6.75 metric tons.

Hydrocarbon seal configuration: Seals of dissimilar designs and materials are required for all pressure boundaries / barriers. Metal seals are preferred for all primary seals.

All configurations shall be “scoop proof” or utilize any other appropriate configuration, such that the contact elements are fully protected during engagement.

If orientation is critical then keyed interfaces or alternative solutions may be required.

Connectors shall be interchangeable (intermateable) between mating halves and shall not be used as matched sets in any of the testing specified in this document.

The wet-mate interface shall be designed to tolerate debris present in the interface during normal mating operations, also debris tolerant (as defined in step 10.4). Additional testing may be agreed to with the client.

9 Optical Performance Requirements

Optical performance as defined herein is for all temperatures and pressures defined Section 7 - Service Conditions. The following optical loss levels are based on the maximum allowable losses per contact pair or splice while the equipment is operating in a steady-state, or in-situ condition, as opposed to losses attributed to measurements or monitoring during installation and running/recovery of the system.

Certain sensor systems may require more stringent loss performance which shall be defined in the Project Interface Datasheet found in Appendix A for a given sensor system and application.

The specific optical loss requirements shall ultimately be derived from the overall system loss budget as defined by the client for a given application, as the OFS must be considered as an integral subsystem in the overall system from the sensor to the output / control panel.

Table 2: General Optical Loss Levels

Single Mode	Measurement	Typical Test Wavelength (nm)	
	Insertion Loss	1310 & 1550	≤ 0.5
	Return Loss	1310 & 1550	≤ -35
B. Multimode	Insertion Loss	850 & 1310	≤ 0.5
	Return Loss	850 & 1310	≤ -35

Loss testing shall be made using the appropriate test equipment, power source (LED or LASER – fixed or tunable), launch conditions, and measurement quality test leads matching the fiber characteristics (size and numerical aperture). Refer to IEC 61300 for Insertion Loss (attenuation) and Return Loss testing methods. Optical test equipment shall be based on standard commercially available equipment conforming to industry standards regarding power output and spectral tolerance. Equipment needed for testing outside this range shall be identified as a requirement on the Project Interface Datasheet
.
The power levels for performance and testing of the OFS equipment is designated as commercial data transmission power levels using standard telecommunication test equipment. Any testing requiring high optical power (greater than 0.1W) shall be defined by the client in the Project Interface Datasheet found in Appendix A.

Loss variation shall be ≤ 0.5 (dB) for spectral flatness in C and L wavelength bands.

Loss tests are to be made bi-directionally unless noted otherwise in the Project Interface Datasheet found in Appendix A.

Alternative project specific wavelengths/bands may be required and may have differing performance/acceptance criteria – this shall be documented on the Project Interface Datasheet found in Appendix A.

Loss variation or progressive loss degradation related to the installed life-cycle of system can affect the overall performance of the optical sensor system, thus performance shall remain stable as defined in the optical performance table. Transient loss events are acceptable provided the duration and magnitude of any increase, spurious performance and/or optical discontinuities are less than what is required by the sensor system provider.

10 Qualification Test Requirements

The following basic optical tests are to be performed at various stages during the test program to demonstrate optical performance is in conformance with the requirements. All optical tests shall be conducted in typical atmospheric conditions unless noted otherwise.

All applied pressure and temperature levels shall be recorded and provided as objective quality evidence of the tests completed. The test charts shall be suitably identified including as a minimum the start/stop times, dates of test, part numbers and serial numbers of UUT components, test procedure and technician and any necessary Third Party Inspector (TPI) sign off.

All hold or dwell times for pressure shall be with the pressure source isolated from the UUT for the period stated.

10.1 Insertion Loss Test (IL)

Test objective: This test is used to establish the initial insertion loss baseline in accordance with the maximum loss requirements, and repeated as a characterization test to validate that the loss does not exceed the stated requirements before and after environmental stress testing.

Number of connectors to be tested:	All contact pairs, splices and penetrators
Test conditions:	Ambient environment - Test wavelengths and General Optical Loss Levels as per Table 2
Test Acceptance Criteria:	Per Table 2: General Optical Loss Levels per contact pair, splice or penetrator

10.2 Return Loss Test (RL)

Test objective: This test is used to establish the initial return loss baseline in accordance with the maximum loss requirements, and repeated as a characterization test to validate that the loss does not exceed the stated requirements before and after environmental stress testing.

Number of connectors to be tested:	All contact pair designs, splices or penetrator
Test conditions:	Ambient environment - Test wavelengths per Table 2: General Optical Loss Levels
Test Acceptance Criteria:	Per Table 2: General Optical Loss Levels per contact pair, splice or penetrator

10.3 Hydrostatic Pressure Test

Test objective: This test is used to apply physical stress to the UUT to determine its ability to maintain sealing and functional and mechanical integrity during test exposure, and functional integrity after test exposure.

Connectors or penetrators to be tested:

- Individual pressure barrier components; open-face and reverse-face pressure exposure
- Mated integrity of all connection interfaces

10.3.1 Test conditions and durations:

The individual pressure barrier components shall be tested at PT per Table 1: Service and Test Conditions and Table 3: Hydrostatic Pressure Cycles.

For mated integrity pressure exposure Insertion Loss and Return Loss shall be measured in the pressure vessel at zero and maximum pressures. Test pressure exposure shall be Pw per Table 1: Service and Test Conditions.

Table 3: Hydrostatic Pressure Cycles

Cycle	Pressure and duration	Temperature	Comment
1	15 minutes @ 5.2MPa (750 psig)	ambient	Apply pressure, hold, and then lower to zero psig.
2	15 minutes @ test pressure (PT)	ambient	Apply pressure, hold, and then lower to zero psig.
3	15 minutes @ test pressure (PT)	ambient	Apply pressure, hold, and then lower to zero psig.
4	60 minutes @ test pressure (PT)	ambient	Apply pressure, hold, and then lower to zero psig.

10.3.2 Test Acceptance Criteria:

Once pressure has stabilized there shall be no evidence of pressure loss as defined in ISO 13628-4. Deviations from the initial stabilized pressure due to temperature variations are acceptable.

Before, during (when applicable) and after the test:

- There shall be no visible damage or pressure leakage
- The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels.

10.4 Functional Mate / Demate Test in Turbid Conditions

Test objective: This test verifies the functionality of the wet-mate connectors when subjected to mating and demating in contaminated liquid and exposed to pressure during and after multiple mating cycles.

Number of wet-mate connectors to be tested: 1 pair

10.4.1 Test conditions and durations:

Perform initial optical loss tests at ambient temperature and atmospheric pressure prior to commencing test.

Bench test connectors by dry-mating and de-mating 5 times.

Repeat optical loss tests after drymate tests and prior to commencing wet-mate test.

Establish the test media consisting of simulated seawater (35,000 PPM NaCl), 1% river silt (2 to 50µm) and 0.5% sharp sand (50 to 500µm). The test media shall be agitated throughout the test.

Install the UUT into test apparatus.

The first mating cycle shall be submerged (wet) at atmospheric pressure with all subsequent mating cycles submerged (wet) at elevated test pressures.

The second mating cycle shall be at 17.2MPa (2,500 psig).

The balance of the mating cycles to 25 shall be at maximum external seawater hydrostatic working pressure (Pw).

Insertion loss and return loss shall be measured and recorded at pressure as follows:

After cycle 1, 2, 3, 4 & 5, cycle 10, 15, 20 and at 25.

Final loss measurements shall be taken submerged (wet) at atmospheric pressure.

10.4.2 Test Acceptance Criteria:

Once pressure has stabilized there shall be no evidence of pressure loss as defined in ISO 10423. Deviations from the initial stabilized pressure due to temperature variations are acceptable.

Before, during and after the test:

- There shall be no visible damage or pressure leakage
- The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels

10.5 Functional Mate/Demate Test in Cold Conditions

Test objective: This test simulates pre-installation dry-mating cycles of any or all of the OFS interconnections (wet-mates or drymates) conducted in the offshore environment in cold regions of the world to verify the functional integrity of the connector during and after drymate engagement cycles at atmospheric pressure.

Number of connectors to be tested: 1 pair of each type

10.5.1 Test conditions and durations:

Perform initial bench optical loss tests at ambient temperature and atmospheric pressure prior to commencing test.

Place the UUT in a suitable test chamber to enable drymate mating cycling at -18°C (0°F) test temperature.

The optical loss shall be measured and recorded at ambient pressure before, during and after 3 cold mating cycles.

10.5.2 Test Acceptance Criteria:

Before, during and after the test:

- There shall be no visible damage
- The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels.

10.6 Misalignment Test

Test objective: This test verifies the ability of the wetmate connector to physically engage and properly complete continuity when misaligned to a maximum offset as defined by the client equipment tolerance requirements.

Number of connectors to be tested: 1 pair of wetmate connectors

10.6.1 Test conditions and durations:

Perform optical loss tests prior to commencing the test.

Due to the variation in tolerancing requirements of the various tree manufacturer interfaces, the actual tolerance requirements for this test will need to be determined by the tree manufacturer for the specific trees configuration.

Establish the maximum misalignment between the wetmate connector halves as defined by the client and their respective equipment worst-case tolerances. The alignment definitions are cited in the glossary to define and clarify.

Pressure, test	-	*1.5 x external working pressure (Pw)
Temperature	-	ambient temperature
Environment	-	tap water
Duration	-	8 mating cycles minimum with 2 misalignment mating cycles in each of The following quadrants: +x/+y, +x/-y, -x/+y, -x/-y

*Note: Although it is preferred, it is not mandatory to conduct this test wet, under pressure - the test may be conducted under atmospheric conditions.

10.6.2 Test Acceptance Criteria

Once pressure has stabilized there shall be no evidence of pressure loss as defined in ISO 13628-4. Deviations from the initial stabilized pressure due to temperature variations are acceptable.

Before, during and after the test:

- There shall be no visible damage or pressure leakage (if applicable)
- The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels

10.7 Thermal Shock Test - Unmated, Non-functional

Test objective: This test verifies that the elements and assemblies forming the OFS are capable of maintaining functional and sealing integrity before and after thermal shock testing that simulates shipping and storage conditions.

Number of connectors, penetrators or splices to be tested:

1 of each uniquely different terminated component (identical terminations used in multiple locations only require a single type-test to qualify).

10.7.1 Test conditions and durations:

The following tests are conducted at atmospheric pressure and shall demonstrate that thermal shock will have no detrimental effect on the connector and/or feedthrough assembly. Each assembly shall be thermal cycle tested in its final assembled unmated condition.

Conduct an open-face hydrostatic pressure test in accordance with Section 10.3 on the barrier containing element of the connector or penetrator before and after the thermal shock exposure. Perform optical loss tests before and after the hydrostatic pressure tests.

10.7.2 High Temperature Test:

Using the appropriate environmental chamber(s), subject the UUT to thermal cycling from ambient temperature to 70°±4°C (158°±7.2°F) in air followed by rapid immersion in water at 3°±3°C (37.4°±5.4°F). Allow the UUT to remain at maximum and minimum temperatures for 4 hours minimum dwell. Repeat for 3 cycles then return to ambient temperature.

After stabilizing at ambient temperature, conduct optical loss tests.

10.7.3 Low Temperature Test:

Using the appropriate environmental chamber(s), subject the UUT to thermal cycling from ambient temperature to -40°±4°C (-40°±7.2°F) in air followed by rapid immersion in water at 3°±3°C (37.4°±5.4°F). Allow the UUT to remain at minimum and maximum temperatures for 4 hours minimum dwell. Repeat for 3 cycles then return to ambient temperature.

After stabilizing at ambient temperature, conduct optical loss tests.

10.7.4 Test Acceptance Criteria:

Before and after the test:

- There shall be no visible damage or pressure leakage
- The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels.

10.8 Flooded Termination Test

Test objective: This test verifies the functional and sealing integrity of the final termination barrier of the connector, penetrator or splice termination when subjected to a simulated failure of the primary barrier systems.

Number of connectors, penetrators or splices to be tested:

1 of each uniquely different terminated component (identical terminations used in multiple locations only require a single type-test to qualify).

The UUT shall have only the final barrier of the optical fiber system intact simulating a flooded termination.

10.8.1 Test conditions and durations:

The test fluid shall be water unless otherwise specified by the client/operator.

The optical loss shall be measured on the mated connector or penetrator in a pressure vessel, submerged, at ambient pressure and temperature. The vessel temperature and pressure shall be raised to the maximum test temperature (TT) and working pressure (PW) as defined in Table 1: Service and Test Conditions, and maintained under these conditions for a period of 1200 hours (50 days). Throughout the test period, the optical loss shall be measured and recorded twice daily during normal working hours.

Upon completion of the test period, the pressure and temperature shall be permitted to gradually return to ambient with optical loss measured and recorded prior to removal from the vessel.

10.8.2 Test Acceptance Criteria:

Once pressure has stabilized there shall be no evidence of pressure loss as defined in ISO 10423. Deviations from the initial stabilized pressure due to temperature variations are acceptable.

Before, during and after the test:

- There shall be no visible damage or pressure leakage.
- The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels.

10.9 Individual Seal Pressure Test

10.9.1 Individual Seal Hydrostatic Pressure Test:

Test objective: This test verifies the liquid sealing capability of all individual pressure barrier sealing elements independently of other sealing elements in the barrier element.

Number of seals to be tested: 1 of each uniquely different seal configuration.

10.9.2 Test conditions and durations:

The individual primary pressure-containment seals are to be installed in relevant interfaces with the secondary seals not installed, removed or negated, and hydrostatically pressure tested (PT) in tap water in accordance with Table 1: Service and Test Conditions and Table 4: Hydrostatic Pressure Cycles.

The individual secondary pressure-containment seals are to be installed in relevant interfaces with the primary seals not installed, removed or negated, and hydrostatically pressure tested (PT) in tap water in accordance with Table 1: Service and Test Conditions and Table 4: Hydrostatic Pressure Cycles.

Bidirectional seals, whether primary or secondary, shall be hydrostatically pressure tested (PT) in tap water in accordance with Table 1: Service and Test Conditions and Table 4: Hydrostatic Pressure Cycles in both directions.

Table 4: Hydrostatic Pressure Cycles

Cycle	Pressure and duration	Temperature	Comment
1	15 minutes @ 5.2MPa (750 psig)	ambient	Apply pressure, hold, and then lower to zero psig.
2	15 minutes @ test pressure (PT)	ambient	Apply pressure, hold, and then lower to zero psig.
3	15 minutes @ test pressure (PT)	ambient	Apply pressure, hold, and then lower to zero psig.
4	60 minutes @ test pressure (PT)	ambient	Apply pressure, hold, and then lower to zero psig.

10.9.3 Test Acceptance Criteria:

Once pressure has stabilized there shall be no evidence of pressure loss as defined in ISO 10423. Deviations from the initial stabilized pressure due to temperature variations are acceptable.

During and after the test:

- There shall be no visible damage or pressure leakage

NOTE: Purpose-built test fixturing may be used to replicate the sealing structure to facilitate completion of testing

10.9.4 Individual Seal Gas Pressure Test:

This test shall be conducted if required by the client to comply with PSL 3G. In the absence of this requirement, this test may be conducted at the discretion of the OFS supplier, but is not necessary.

Test objective: This test verifies the gas sealing capability of all individual pressure barrier sealing elements independently of other sealing elements in the barrier element.

Number of seals to be tested: 1 of each uniquely different seal configuration

10.9.5 Test conditions and durations:

In nitrogen (N_2) gas, the individual primary pressure-containment seals are to be installed in relevant interfaces with the secondary seals not installed, removed or negated, and gas pressure tested to the working pressure (PT) in accordance with Table 1: Service and Test Conditions and Table 5: Gas Pressure Cycles.

In nitrogen (N_2) gas, the individual secondary pressure-containment seals are to be installed in relevant interfaces with the primary seals not installed, removed or negated, and gas pressure tested to the working pressure (PT) in accordance with Table 1: Service and Test Conditions and Table 5: Gas Pressure Cycles.

For bidirectional seals, whether primary or secondary, gas pressure test to the working pressure (PT) in accordance with Table 1: Service and Test Conditions and Table 5: Gas Pressure Cycles in both directions.

Table 5: Gas Pressure Cycles

Cycle	Pressure and duration	Temperature	Comment
1	15 minutes @ 5.2MPa (750 psig)	ambient	Apply pressure, hold, and then lower to zero psig.
2	15 minutes @ test pressure (PT)	ambient	Apply pressure, hold, and then lower to zero psig.
3	15 minutes @ test pressure (PT)	ambient	Apply pressure, hold, and then lower to zero psig.
4	60 minutes @ test pressure (PT)	ambient	Apply pressure, hold, and then lower to zero psig.

10.9.6 Test Acceptance Criteria:

Once pressure has stabilized there shall be no evidence of pressure loss as defined in ISO 10423. Deviations from the initial stabilized pressure due to temperature variations are acceptable.

During and after the test:

- There shall be no visible damage, pressure drop or bubble leakage as defined in ISO 10423, Annex F.

NOTE: Purpose-built test fixturing may be used to replicate the sealing structure to facilitate completion of testing.

10.10 Mechanical Shock Test - Unmated, Non-functional

Test objective: To ensure that typical mechanical shock loads attributed to storage, shipping and handling will not impair performance of any part of the feedthrough system once installed and mated.
Number of assemblies (connectors or penetrators) to be tested: 1 of each unique interfaces, unmated (non-functional).

10.10.1 Test conditions and durations:

Conduct an open-face hydrostatic pressure test in accordance with section 10.3 on the barrier containing element of the connector or penetrator before and after the mechanical shock exposure. Perform optical loss tests before and after the hydrostatic pressure tests.

Perform optical loss tests prior to commencing test (post-hydrostatic test loss results can serve this purpose).

Attach the UUT to the shock platen representing the typical packaging and shipping configuration for OFS assemblies. Secure to the platen by rigidly fastening from movement relative to the platen.

Mechanical shock parameters are defined in ISO 10423 and ISO 13628-6 unless otherwise identified in the Project Interface Datasheet.

Perform optical loss tests after shock application.

10.10.2 Test Acceptance Criteria:

After test:

- There shall be no visible damage or pressure leakage
- The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels.

10.11 Vibration Test: Mated, Functional

Test objective: To confirm the functional integrity of the feedthrough system assembled and mated representing the final installed configuration when subjected to vibration that may be induced from flow in pipes or through the tree, and by rotating machinery. This is an ambient temperature test at atmospheric pressure – if the test needs to be conducted under various temperature and pressure ranges, these requirements shall be identified on the Project Interface Datasheet.

Number of assemblies (connectors or penetrators) to be tested: 1 of each unique interfaces, mated (functional) as in normal deployment mode.

10.11.1 Test conditions and durations:

Conduct an open-face hydrostatic pressure test in accordance with section 10.3 on the barrier containing element of the connector or penetrator before and after the vibration exposure. Perform optical loss tests before and after the hydrostatic pressure tests.

Perform optical loss tests prior to commencing test (post-hydrostatic loss test results can serve this purpose).

Engage each unique interface as intended for normal installation and deployment.

Attach the UUT to the vibration platen by replicating the XT mounting structure. This typically involves hard-mounting one or both connector halves or penetrator assembly.

Measure and record optical loss performance prior to and after vibration application.

During vibration application, monitor for any optical discontinuity exceeding 0.5dB. For sensor applications where specific performance monitoring with the system interrogator is necessary, this shall be coordinated through the client and the sensor company using the Project Interface Datasheet found in Appendix A.

Vibration parameters are defined in ISO 10423 and ISO 13628-6 unless otherwise identified in the Project Interface Datasheet found in Appendix A.

Vibration excitation shall be applied to three mutually perpendicular axes.

10.11.2 Test Acceptance Criteria:

After test:

- There shall be no visible damage or pressure leakage after vibration exposure.

- There shall be no sustained increased signal loss or signal discontinuity exceeding 0.5db during vibration application.
- The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels.

10.12 Cyclical Pressure and Temperature Test per ISO 10423 PSL 3 & 3G, Annex F, F.1.11

Gas testing shall be conducted if required by the client to comply with PSL 3G. In the absence of this requirement, this test may be conducted at the discretion of the OFS supplier, but is not necessary.

Test objective: To confirm the functional integrity of the feedthrough system assembled and mated representing the final installed configuration when subjected to synergistic pressure and temperature cycling.

Number of samples to be tested:

1. One complete feedthrough system comprising wetmate, drymate connectors, penetrators and splices (to facilitate testing, the wetmate portion may be tested separately from the drymate or penetrator portion).
2. Individual seals as defined in section 10.9.

Test (a) is a functional test and is required to qualify the performance of the full-up, mated system configuration.

ISO 10423 Annex F, F1.11 - PSL 3G requires the testing to also be completed hydrostatically in liquid media comprised of a water/glycol mixture to permit testing to the pressure and thermal extremes, but a gas pressure control test shall be conducted at PW at ambient temperature using gas (N_2) before and after the PR2 cycling with (1) a minimum duration at PW of 1 hour, then (2) at 5% to 10% of PW for a minimum duration of 1 hour.

For the PSL 3G test, the gas decompression rate shall be controlled by decreasing from PW to 20.7MPa (3,000psig) during the course of 1 hour minimum, then from 20.7MPa (3,000psig) to atmospheric pressure at a constant rate over a minimum of 3 hours. Upon reaching atmospheric pressure, permit the UUT to dwell for a minimum of 2 hours before proceeding with next cycle or removal of UUT. This is not intended to be a rapid gas decompression (RGD) test, for such testing, refer to NORSOK M-710, Annex B, or refer to client specified parameters identified in the Project Interface Datasheet found in Appendix A.

10.12.1 Test conditions and durations:

Refer to Table 7 for the test profile:

- Temperature range: TT per Table 1: Service and Test Conditions
- Pressure range: PW per Table 1: Service and Test Conditions
- Number of pressure / temperature cycles: per ISO 10423, Annex F.1.11 – refer to Table 7

10.12.2 Test Acceptance Criteria:

<u>PSL 3 test (hydrostatic):</u>

Before, during and after the test:

The IL and RL shall be measured and recorded at the beginning and end of all hold periods as defined in ISO 10423, Annex F.1.11. The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels.

There shall be no visible damage or pressure leakage throughout the test and upon conclusion.

PSL 3G test (gas):

Before, during and after the test:

The IL and RL shall be measured and recorded at the beginning and end of all hold periods as defined in ISO 10423, Annex F.1.11. The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels.

There shall be no visible damage or pressure leakage throughout the hydrostatic portion of the test.

Before and after the pressure and temperature exposure cycling (before step A and after step O in Figure 8), the UUT shall be subjected to gas testing first to Pw, then at 5% to 10% of Pw at ambient temperature and shall show no indication of bubble leakage during the hold period indicated (ref. ISO 10423 Annex A F.1.6.3b).

ISO 10423 Annex F.1.11 - PR2 Pressure and Temperature Synergistic Exposure

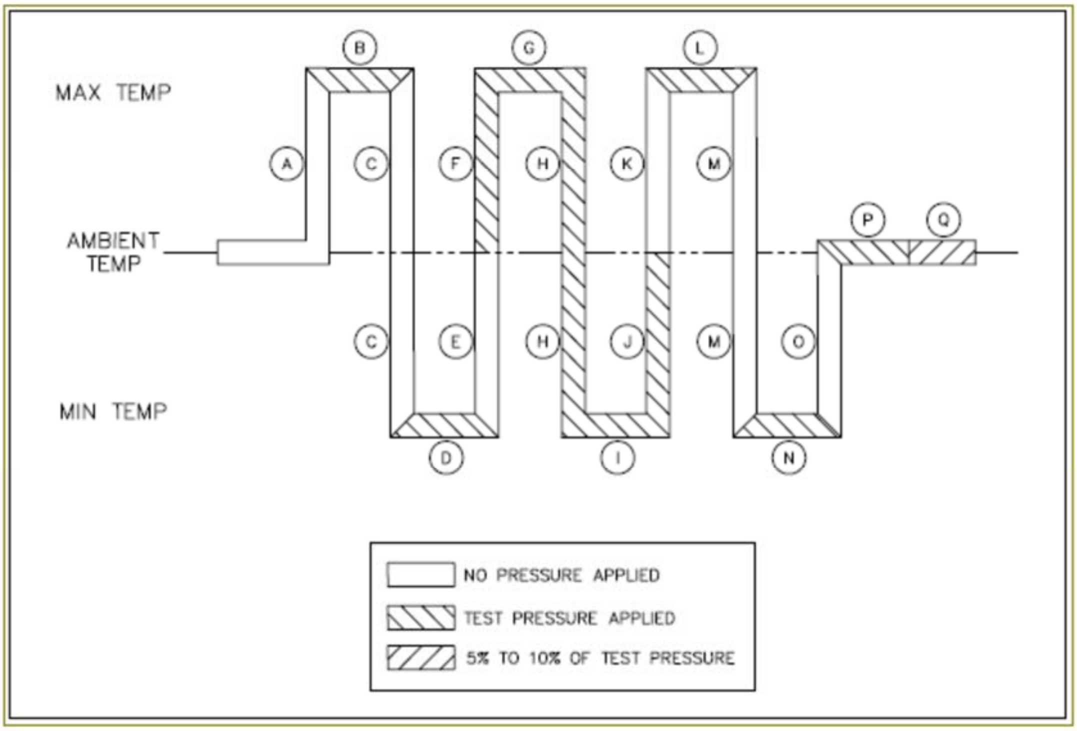

Figure 8: ISO 10423 Annex F.1.11 – PR2 Pressure and Temperature Synergistic Exposure

10.13 Helium Leak Test

Test objective: To ensure that each pressure barrier sealing element is verified as hermetic in terms of preventing helium from bypassing the sealing elements. This test is considered a control or characterization test and is repeated at various points before and after environmental stress tests.

Number of connectors, penetrators and splices to be tested:

All individual pressure barrier components.

10.13.1 Test conditions and durations:

Temperature: Ambient environment

Test shall be performed using a mass spectrometer, or suitable helium leak test detection equipment. A vacuum shall be applied to one side of the UUT to achieve a threshold of approximately 10mTorr or less. Helium shall then be applied in a controlled manner to the atmospheric face of the UUT. The helium leak rate shall be recorded after 1 minute exposure.

10.13.2 Test Acceptance Criteria:

Helium leak rate shall be less than 1 x 10-6 cm3/sec.

10.14 Partial Wetmate Connector Mating Test

Test objective: To ensure that various partial mating states of the wetmate connectors will not impair their optical functionality. This test is conducted in water. Partial mating may occur during field testing or partial activation of a horizontal actuation of the wetmate connector.

Number of facing wetmate connectors to be tested: 1 pair

10.14.1 Test conditions and durations:

Perform initial optical loss tests at ambient temperature and atmospheric pressure prior to commencing test.

Install the UUT into and appropriate test apparatus to control and index engagement displacement of one half relative to the other to achieve mating increments of 25% of the total mating stroke length when optical continuity is initially made.

Conduct 5 mating cycle sets with each cycle comprised of 4 engaging/disengaging cycles by mating 25% and disengaging, then 50% and disengage, then 75% and disengage, and finally 100% and disengage. At each mating increment, measure insertion loss and return loss.

Conduct a total of 5 mating cycle sets, or 20 mating cycle totals.

10.14.2 Test Acceptance Criteria:

After test:

- There shall be no visible damage after mating cycle sets.
- The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels.

11 Factory Acceptance Test (FAT)

11.1 Objective

As a minimum, the FAT shall demonstrate that all connectors and delivered assemblies conform to the optical and mechanical specifications as stated herein.

All applied pressure and temperature levels (other than ambient) shall be recorded and provided as objective quality evidence of the tests completed. The test charts shall be suitably identified including as a minimum the start/stop times, dates of test, part numbers and serial numbers of UUT components, test procedure, technician and any necessary Third Party Inspector (TPI) sign off.

All pressure hold or dwell times shall be with the pressure source isolated from the UUT for the period stated.

These tests shall include as a minimum the following type tests:

11.2 Insertion Loss Test (IL)

Number of connectors to be tested: all contact pair designs, splices or penetrators hence the complete OFS.

11.2.1 Test conditions: Ambient environment - Test wavelengths per Table 2: General Optical Loss Levels

11.2.2 Test Acceptance Criteria: Per Table 2: General Optical Loss Levels per contact pair, splice or penetrator

11.3 Return Loss Test (RL)

Number of connectors to be tested: all contact pair designs, splices or penetrator

11.3.1 Test conditions: Ambient environment - Test wavelengths per Table 2: General Optical Loss Levels

11.3.2 Test Acceptance Criteria: Per Table 2: General Optical Loss Levels per contact pair, splice or penetrator

11.4 Helium Leak Test

Number of connectors to be tested: All individual pressure barrier components

Test is required to verify the integrity of all pressure barrier internal sealing elements.

11.4.1 Test conditions and durations:

Temperature: Ambient environment

Test performed using a mass spectrometer, or helium leak test equipment, a vacuum shall be applied to one side of the UUT to achieve a threshold of approximately 10mTorr or less. Helium shall then be applied to the atmospheric face of the UUT. The helium leak rate shall be recorded after 1 minute exposure.

11.4.2 Test Acceptance Criteria:

Helium leak rate shall be less than 1 x 10-6 cm^3/sec.

11.5 Hydrostatic Pressure Test

Items to be tested:

a. Individual pressure barrier components (open-face exposure)
b. Deliverable assemblies

11.5.1 Test conditions and durations:

Insertion loss and return loss shall be measured before and after pressure exposure. For individual pressure barrier components, the test pressure exposure shall be PT per Table 1: Service and Test Conditions. For deliverable assemblies, the test pressure exposure shall be Pw per Table 1: Service and Test Conditions. The test medium shall be tap water.

Table 6: Hydrostatic Pressure Cycles

Cycle	Pressure and duration	Temperature	Comment
1	15 minutes @ 5.2MPa (750 psig)	ambient	Apply pressure, hold, and then lower to zero psig.
2	15 minutes @ test pressure (PT) for individual components and working pressure (Pw) for assemblies	ambient	Apply pressure, hold, and then lower to zero psig.
3	15 minutes @ test pressure (PT) for individual components and working pressure (Pw) for assemblies	ambient	Apply pressure, hold, and then lower to zero psig.
4	60 minutes @ test pressure (PT) for individual components and working pressure (Pw) for assemblies	ambient	Apply pressure, hold, and then lower to zero psig.

11.5.2 Test Acceptance Criteria:

Once pressure has stabilized there shall be no evidence of pressure loss as defined in ISO 10423. Deviations from the initial stabilized pressure due to temperature variations are acceptable.

Before, during (where applicable) and after the test:

- There shall be no visible damage or pressure leakage.
- The Insertion and Return Losses shall be in accordance with Table 2: General Optical Loss Levels.

11.6 Gas Pressure Test

This test shall be conducted as required by the client. In the absence of this requirement, this test may be conducted at the discretion of the OFS supplier, but otherwise is not necessary. When this test is required by the client in the absence of client-defined test criteria, the test parameters shall be as defined below.

Test objective: This test verifies the gas sealing and functional capability of the completed assembly being installed into the XT equipment (i.e. XTFS assembly installed into the master or composite valve block).

11.6.1 Test conditions and durations:

In nitrogen (N_2) gas, the assembly shall be installed into appropriate test fixturing replicating the final installation configuration to the XT and pressure tested to the working pressure (PW) in accordance with Table 1: Service and Test Conditions and Table 5: Gas Pressure Cycles.

Table 7: Gas Pressure Exposure

Cycle	Pressure and duration	Temperature	Comment
1	60 minutes minimum @ PW Note: The test exposure duration is subject to client definition.	ambient	Apply pressure, stabilize, hold, and then lower to zero psig in a controlled manner to avert decompression damage.

11.6.2 Test Acceptance Criteria:

Once pressure has stabilized there shall be no evidence of pressure loss as defined in ISO 13628-4. Deviations from the initial stabilized pressure due to temperature variations are acceptable.

During and after the test:

- There shall be no visible damage, pressure drop or bubble leakage as defined in ISO 10423, Annex F.

Appendix A: Project Interface Datasheet (PID)

Item	Description	Document Section
1.0	Define external interfaces: Fiber specification. Downhole gauge (DHG) cable – provide cable datasheet and minimum 1 m sample. SCM Jumper requirements – SCM mounting base wetmate connector, jumper length, configuration (single line, bifurcated)	Section 5
2.0	Define internal interfaces with XT equipment; including misalignment tolerances and engagement speed, materials, etc.	Section 5 Section 2.2
3.0	Define service class and conditions: Working pressure and temperature range PSL 3 or PSL 3G	Section 8, Table 1
4.0	Define chemical exposure levels and compositions if other than specified herein: Reservoir composition – liquid and gas Completion & workover fluid compositions Chemical injection	Section 8
5.0	Define optical loss requirements If different than defined herein, provide specific details for loss requirements, test methods and the need for special test equipment (e.g. specific sensor system interrogator).	Section 8, Table 2
6.0	Define vibration parameters, feedthrough system optical performance requirements and test methods if different than as stated herein.	Section 9.11

This Project Interface Datasheet shall be used to define all additional design, functional and test requirements exceeding the requirements specified herein. If optical testing is required beyond what is stated herein, it is incumbent on the client and sensor company to identify the necessary test requirements and equipment and convey this to the connector equipment supplier as a front-end activity.

This Project Interface Datasheet shall be used to document all additional mechanical interfaces exceeding the requirements specified herein. This shall include mechanical interfaces with client equipment for all elements of the OFS, as well as cable / control line interfaces for the downhole and subsea transmission elements. In most cases, it will be necessary to provide samples of the control line (DHG cable) to the connector equipment supplier as a front-end activity.

12 Bibliography

1. ISO 10423 – Petroleum and natural gas industries – Drilling and production equipment – Wellhead and Christmas tree equipment
2. ISO 13628-3 - Petroleum and natural gas industries -- Design and operation of subsea production systems -- Part 3: Through flowline (TFL) systems
3. ISO 13628-4 - Petroleum and natural gas industries -- Design and operation of subsea production systems -- Part 4: Subsea wellhead and tree equipment
4. ISO 13628-6 - Petroleum and natural gas industries -- Design and operation of subsea production systems -- Part 6: Subsea Control Systems
5. API 6A – Specification for Wellhead and Christmas Tree Equipment
6. API 17D - Specification for Subsea Wellhead and Christmas Tree Equipment
7. API 17 F – Verify title
8. ISO 15156-1 - Petroleum and natural gas industries – Materials for use in H2S-containing environments in oil and gas production – Part 1: General principles for selection of cracking-resistant materials
9. NACE – MR0175 – Metals for Sulphide Stress Cracking and Stress Corrosion Cracking Resistance in Sour Oilfield Environments
10. TR 2368 (former NHT-152-00073) – Requirements to Subsea Mateable Electrical/Optical Connectors
11. IEC 61300-3-4 – Fiber optic interconnecting devices and passive components – basic test and measurement procedures – examinations and measurements - attenuation
12. IEC 61300-3-6 – Fiber optic interconnecting devices and passive components – basic test and measurement procedures – examinations and measurements – return loss
13. NORSOK M 710 Elastomeric Materials
14. SEAFOM Website – www.seafom.com

NOTE: Current revisions of all specifications and standards are implied herein unless otherwise specified.