



Exploration & Production

GENERAL SPECIFICATION

PIPELINES - RISERS

GS PLR 160

Design, manufacturing and testing of umbilicals

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1. Scope

This General Specification is applicable to the design, procurement, manufacturing and testing of subsea control umbilicals (the load out, transportation and installation are covered by **GS PLR 407, GS PLR 408 and GS PLR 409**).

Further information on the scope is provided in section 4 hereof.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
ISO 13628-5	Design and operation of subsea production systems – Subsea umbilicals
ISO 13628-8	Design and operation of ROV interfaces on subsea production systems
DNV OS-F101	Submarine pipeline systems
DNV OS-F201	Dynamic risers
BS EN 10257-2	Zinc or zinc alloy coated non-alloy steel wire for armouring either power cables or telecommunication cables. Submarine cables
ASTM E562	Standard Test Method for Determining Volume Fraction by Systematic Manual Point Count
ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A450	Standard Specification for General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes
ASTM G48	Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution
ASTM A262E	Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A789/789M	Standard specification for seamless and welded ferritic / austenitic stainless steel tubing for general service
ASME section IX	Code for welding and brazing qualification
ASME section V	Non destructive methods of examination
EN 473	General principles for qualification and certification of NDT personnel



Reference	Title
AS 4059	Cleanliness classification for hydraulic fluids
IEC 60228	Conductors of insulated cables
ISO 9001:2000	Quality Management Systems - Requirements

Professional Documents

Reference	Title
DNV RP 305	Stability of submarine pipelines

Regulations

Reference	Title
DNV Rules	DNV Rules for Planning and Execution of Marine Operations

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS PLR 001	Documentation requirements
GS PLR 002	Organisation of the design works
GS PLR 100	Submarine pipelines systems
GS PLR 151	Design of steel catenary riser system
GS PLR 407	Load out of submarine cables, umbilicals and flexible pipes
GS PLR 408	Transportation of submarine cables, umbilicals and flexible pipes
GS PLR 409	Installation of submarine cables, umbilicals and flexible pipes
GS PVV 614	Welding of Duplex and Super Duplex stainless steel
GS SPS 009	Corrosion protection of subsea stations
GS SPS 019	Subsea production control system
GS SPS 023	Cleaning and flushing of hydraulic systems
GS COR 100	Design of cathodic protection of offshore structures
GS COR 201	Supply of sacrificial anodes
GS COR 350	External protection of offshore and related structures and equipment by painting

3. Definitions and abbreviations

Definitions and abbreviations used in the present specification are in accordance with the [ISO 13628-5](#). Additional terms are defined below.

3.1 Definitions

COMPANY	TOTAL
Accumulated Plastic Strain	Sum of plastic strain from each strain cycle during the process considered (manufacturing, handling, installation).
Field proven solution	Umbilical system or part of the umbilical system previously qualified or already in use assuring the giving function in similar conditions to those of the project
Super Duplex	Refers to 25% Cr Ferritic / Austenitic stainless steel
Termination Interface	Mechanism which forms the transition between the umbilical and the termination (subsea or topside). Also refer to ISO 13628-5 definitions.

3.2 Nomenclature and abbreviations

APS	Accumulated Plastic Strain
FAT	Factory Acceptance Test
HCF	High Cycle Fatigue (elastic region)
LCF	Low Cycle Fatigue (plastic region)
MQP	Manufacturing Quality Plan
NDT	Non Destructive Test
PE	Poly Ethylene
PPS	Project Particular Specification
SCF	Stress Concentration Factor
SDU	Subsea umbilical Distribution Unit
SUT	Subsea Umbilical Termination
TDP	Touch Down Point
VIV	Vortex Induced Vibration
WPQ	Weld Qualification Process

4. Applicability and limitations

This specification covers the minimum requirements, provides recommendations and guidelines as well as selects the reference documents for the design, procurement, manufacturing and testing of subsea umbilical systems.

4.1 Applicability

This specification addresses both static and dynamic application of umbilicals, including deepwater application.

This specification applies to control umbilicals. It may be also applied to work-over umbilicals.

Design, procurement, manufacturing and testing activities involve:

- Engineering the umbilical structure, internal components and its ancillary equipment (end fittings, terminations, buoyancies ...), engineering the behavior of the umbilical during installation and in service, including defining the riser configuration,
- Procuring materials, manufacturing, assembling, inspecting, testing and storing all umbilicals and associated equipment,
- Verifying that all goods and services to be delivered meet the specified requirements, and providing adequate documentation.

4.2 Basic principles

The design, procurement, manufacturing and testing shall be performed according to the **GS PLR 100** and **GS PLR 002**.

In addition, the present General Specification amends, replaces or supplements various sections of [ISO 13628-5](#).

5. Design brief and deliverables

The design of the umbilical system shall be documented in details. Detailed drawings of the umbilical cross section and ancillary equipment shall be disclosed.

The validity of the software used for the calculations shall be demonstrated prior to the start of the design.

Behaviour of the umbilical during installation and in service shall be assessed. Associated detailed documentation shall be produced.

Design documentation shall be provided according to [GS PLR 001](#) and Prime References requirements.

Documentation shall be issued early enough to allow for design review and approval prior to the start of procurement and manufacturing.

6. COMPANY design premises

6.1 General

The information required to design an umbilical is defined in the [GS PLR 100](#) and the [ISO 13628-5](#).

The information shall be collected prior to start of design activities and gathered into the design basis document as required in the [GS PLR 100](#) and the [GS PLR 001](#).

6.2 Field layout data

The following shall be provided:

- Field location.
- Field description and layout including the location of the surface facilities, umbilicals, flowlines, risers, subsea manifolds and wells, anchoring lines. Each line shall be referenced, each coordinate shall be indicated for terminations, hang-offs, manifolds, wells ...
- Surface facility layout.
- Umbilicals functional line diagrams including all electrical and hydraulic connections.
- Service life.

6.3 Functional data

The following functional requirements for each component of the umbilical shall be specified. These requirements shall take into account redundancy, flow assurance and pressure drop considerations.

Umbilicals description:

- Service: Production control/ Water injection control/ Gas injection control
- Number off

- Configuration: static/ dynamic / buried / unburied
- Length: contingencies should be taken to consider possible field layout evolutions
- Hang-off point and termination
- In-situ construction constraints (e.g. J-tube characteristics, minimum bending radius)

Electrical cables data:

- Type: single/ pair/ triad/ quad/ coaxial/ other
- Number off
- Description
- Power on signal
- Cross sectional area
- Voltage
- Shielding
- Loop resistance
- Capacitance
- Inductance
- Conductance
- Attenuation at the required frequencies
- Cross talk at the required frequencies
- Material

Hydraulic tubes data:

- Service: hydraulic/ chemical injection/ methanol injection/ other
- Number off
- Inside diameter
- Maximum and minimum allowable operating pressure and design pressure
- Maximum and minimum allowable operating temperature and design temperature
- Fluid description
- Fluid density
- Fluid viscosity
- Fluid maximum flowrate
- Cleanliness requirements according to [AS 4059](#) classification

Fibre optic data requirements

- Type
- Number off

- Size
- Mode (multi, single), wavelength
- Transfer rate
- Attenuation

6.4 Meteocean data

The requirements from **GS PLR 151** shall be satisfied.

6.5 Geotechnical and geophysical data

The requirements from **GS PLR 151** shall be satisfied.

6.6 FPS motions characteristics

The requirements are only applicable for dynamic umbilicals.

The requirements from **GS PLR 151** shall be satisfied.

7. Design requirements

7.1 General requirements

The design shall be performed according to the **GS PLR 100**, **GS PLR 102** and **ISO 13628-5**, unless otherwise specified.

The umbilical system shall be sufficiently robust to withstand the exerted forces during manufacture, transport, installation and service life.

The design of the umbilical system shall be performed in every respect of the design life with no repair or replacement allowed.

All material used in the umbilical system shall be compatible with each other, compatible with the fluids and suitable for subsea use under the service conditions during the design life. All material used in the umbilical system shall be documented and approved by COMPANY.

If the umbilical system is not a field proven solution, qualifications and verifications shall be conducted.

Any parameter of the umbilical system which can not be fully described and ascertained must be determined by appropriated test campaign.

All ROV interfaces shall be designed according to **ISO 13628-8**.

7.2 Design load cases combinations

Design load cases combination shall be considered for operation, according to **ISO 13628-5** and **GS PLR 151**, and for installation, according to **DNV Rules**.

Analyses shall be performed for the umbilical and its components for the load conditions considered. The most unfavorable load combination, position and force direction which may act simultaneously shall be considered for the design.

7.3 Safety class

Safety class classification shall satisfy [DNV OS-F201](#) – section 2 / [DNV OS-F101](#) – section C requirements. This will be defined by COMPANY in the PPS.

7.4 Acceptance criteria

The in-service design cases / load combinations are defined in the table below.

Each of these design cases shall be conducted for sufficient environmental loading directions to prove the design.

Typical limiting design criteria are given in the table below:

Design criteria	Acceptance value
Stress in normal operating, installation.	According to ISO 13628-5
Fatigue due to combined load (Wave Frequency, Low Frequency, VIV, etc.), including HCF and LCF.	10 times design life
Maximum allowable total APS level (manufacturing, handling, installation)	15%
Maximum plastic strain level on 1 cycle	2%
Clearance from the FPS, mooring lines, risers and other umbilicals	No clashing (probability of occurrence < 10 ⁻⁴ per design life)
Possible compression in the umbilical	No compression in the umbilical shall be allowed.
Loading on SUT and SDU in normal operation	No tension shall be allowed

7.5 Design studies to be performed

Design studies shall include, as a minimum.

7.5.1 Tubes sizing

The tubes shall be designed to meet the requirements specified as per section 6. Verifications shall be made for the following phases: manufacturing, test, installation, operation, in the loading conditions specified in section 6.

7.5.1.1 Steel tubes

The following verifications shall be performed:

Equivalent stress verification: The hoop stress shall be calculated as per [ISO 13628-5](#). The equivalent stress shall be calculated and verified as per [ISO 13628-5](#) (Von Mises criterion). Equivalent stress shall also include contact stresses.

Collapse, Ovality, Propagating buckling, Load combined criteria, Displacement controlled criteria shall be verified as per [DNV OS F201](#) (for dynamic umbilicals) and [DNV OS F101](#) (for static umbilicals).

Fatigue life: shall be verified as per section 7.5.5

Where required by [DNV OS F201](#) and [DNV OS F101](#), the manufacturing tolerance shall be taken as the most restricting values occurring during the fabrication process (10%).

7.5.1.2 Thermoplastic hoses

Thermoplastic hoses shall be designed as per [ISO 13628-5](#).

7.5.2 Stresses analysis

Particular attention will be taken at the hang-off, sag, bend and TDP area.

The following shall be assessed and justified:

- Loads repartition (tension, bending, torsion) between the components of the umbilical
- Contact and friction loads between components, as well as the friction model used.
- Thermal expansion effects

7.5.3 Dynamic analysis

The dynamic analysis shall be performed according to [GS PLR 151](#) section "Finite elements analysis". This analysis will determine extreme loads (tension and curvature) and fatigue loads on the umbilical.

7.5.4 Interface loads

Loads shall be determined at each umbilical Termination Interface, topside and subsea.

7.5.5 Fatigue analysis

7.5.5.1 General requirements

All components shall be checked for fatigue life according to the methodology described in [GS PLR 151](#). Particular attention will be taken on steel tubes.

A complete fatigue analysis of the umbilical shall be made. It shall be demonstrated that accumulated plastic strain and fatigue damages during tube manufacture, umbilical fabrication, load-out, transportation, installation and operation do not exceed the acceptable level for the design life with a safety factor of 10.

Any fatigue curve applied for the fatigue analysis of umbilical components shall be documented, justified, and subject to COMPANY approval, unless otherwise specified.

7.5.5.2 Methodology

Fatigue calculation report shall be as follow:

All failure mode(s) versus fatigue shall be identified.

The calculations shall be performed considering:

- Low cycle fatigue damage approach when plastic deformation occurs
- SN curve approach when in elastic region with a. linear cumulative damage approach (Palmgren-Miner rule)

Calculation shall be divided in three distinct groups including:

- Handling and fabrication of the tubes, manufacturing, load-out and transportation of umbilicals
- Installation with contingencies considered (retrieval)
- In-place operation

For fatigue damages induced by the handling and fabrication cycles, every step shall be fully described, including as a minimum: Reeling and un-reeling radius of curvature, bending strain induced by roller path, tension and the number of cycles. All contingency steps, e.g. weld repairs shall be considered.

For fatigue damages induced during installation, particular attention shall be paid to the vessel laying system and at the TDP.

Recommended practices to prevent increased fatigue at TDP and overboard chute due to suspending installation operations shall be given.

Dedicated studies shall be performed for each singular point (hang-off, sag, hog, and TDP) of each dynamic umbilical.

Response to wave frequency motions, low frequency dynamic response of the system and vortex induced vibrations shall be considered, for each dynamic umbilical.

The fatigue shall be calculated on annual conditions with an intact mooring for the full life.

The damage shall also be calculated for one year with a broken anchor line, i.e. this shall be used to assess anchorage repair and robustness philosophy of umbilical design.

7.5.5.3 Low cycle fatigue calculations (plastic domain)

The fatigue damage induced by plastic strain of the components during the manufacturing, handling and installation phases shall be evaluated.

7.5.5.4 High cycle fatigue calculations (elastic domain)

This method shall be used when the tube is subject to cyclic loading in elastic region.

For the super duplex tubes, the applicable curve is given in Appendix 3.

The following parameters shall be taken into account:

- Mean stress in the tube due to internal pressure and tension, with the Goodman correction
- The SCF to be used in the welds (to be justified)
- Effect of internal friction between components, helix angle and tolerance on helix angle (calculation methodology for including these effects to be detailed)
- Effect of soft soil at TDP. This includes all assumptions made on soil conditions and at boundary conditions.
- The effect of corrosion

7.5.6 VIV analyses

The dynamic analysis shall be performed according to **GS PLR 151**.

The VIV analysis will demonstrate if VIV suppression devices are required for the dynamic part of the umbilical. If required, they shall be included in the scope of design, supply and installation.

The structural damping factor used in the analyses shall be justified; otherwise, a damping factor of 0,0 shall be used.

Tests will be performed on a sample in operating conditions in order to verify the structural damping factor.

Fatigue due to VIV oscillations shall be addressed.

7.5.7 Interference analysis

Interference analysis shall be performed to confirm that no interference or clashing will occur in between the umbilicals or with the surroundings.

The interference analysis shall be performed according to **GS PLR 151**.

7.5.8 Installation analysis

The installation analysis shall be performed according to **ISO 13628-5** and **DNV rules**.

A Risk Based Analysis shall be conducted.

7.5.9 Recovery analysis

Conditions of recovery shall be identified. The analysis will determine tension, curvature and torsion and ensure that the mechanical characteristics are not overcome. The utilisation factors shall be taken identical to the installation case.

7.5.10 On-bottom stability analysis

The on-bottom stability analysis shall be performed according to **DNV RP E 305**.

The umbilical shall be stable on seabed in the following conditions:

- Lateral stability due to current
- Longitudinal stability due to FPS motions and current

The soil/umbilical lateral and longitudinal friction factor to be used shall be justified, unless otherwise specified.

The dynamic section of the umbilical shall not transfer any tension to the SUT; i.e. even in far conditions, the catenary horizontal tension shall be fully taken by soil friction before the first SUT. If necessary, additional stabilization of the umbilical shall be provided.

7.5.11 Soil modelling

The soil model used for the analyses shall be justified. Trenching effect at the TDP area shall be studied.

7.5.12 Manufacturing analysis

The following shall be assessed:

- Strain during manufacturing: accumulated plastic strain and low cycle fatigue calculation. Axial, bending and torsion strain shall be evaluated and their impact on the weld. It shall be demonstrated that the APS criteria are not exceeded during manufacturing, handling and installation.
- Baushinger effect

7.6 Umbilical design

7.6.1 General requirements

The umbilical shall be designed as compact as possible; the components shall be disposed in order to have a cross section as symmetrical as possible.

The umbilical should be made of one continuous length. No repair, splice or joint shall be permitted in dynamic section. Depending on the umbilical length, splices or joints may be performed on individual component in static section, and shall be subject to COMPANY approval. Any repair that may be performed shall be subject to COMPANY approval. Repair procedure shall be submitted.

The umbilical can contain either steel tubes or thermoplastic hoses. Tube material is specified by COMPANY. Should an alternative be proposed, the material selection shall be justified and subject to COMPANY approval. Solutions with combination of thermoplastic hoses and steel tubes in the same umbilical shall be justified and subject to COMPANY approval.

In addition the following characteristics shall be justified:

Free flooding

Free flooding may be required for deepwater application, for the following reasons:

- To pressure balance the umbilical and reduce friction loads for dynamic applications
- To avoid air being entrapped that would get overpressure and damage the umbilical in case of retrieval

Free flooding shall be obtained either by roving sheathes or by holes in the extruded sheathes.

Torque balance

The umbilical shall be anti-twist designed, preventing rotation and twisting at the required loads.

7.6.2 Umbilical data sheet

The mechanical and material characteristics of the umbilical and its components shall be provided according to Appendix 2.

7.6.3 Electrical cables design

Electrical cables shall be designed according to [ISO 13628-5](#).

Electrical cables design shall meet the requirements specified as per section 666 of the present specification. Electrical cables shall be capable of continuous operation in seawater in the conditions specified in section 6.

In the dynamic section, the electrical cables shall be reinforced with steel armouring or braiding.

7.6.3.1 Cable identification

Each conductor sheath shall be colour-coded as per manufacturer specification and subject to COMPANY approval. Each cable jacket shall be marked to identify its duty, voltage rating, and be colour-coded; each cable shall be over-sheathed using PE and colour-coding.

7.6.3.2 Cable armouring

In case cable armouring is offered, the armour material shall be galvanized steel, and a suitable method shall be proposed to terminate the armour in the electrical connectors.

Grounding procedure shall be detailed in order to avoid earth loops.

Justification shall be given about avoidance of armour corrosion.

Fatigue calculation, according to the methodology stated in this specification shall be assessed to demonstrate the suitability of the selected wire

7.6.4 Fibre optic cable design

Fibre optic cables shall be designed as per [ISO 13628-5](#).

Fibre optic cables design shall meet the requirements specified as per section 6 of the present specification. Fibre optic cables shall be capable of continuous operation in seawater in the conditions specified in section 6.

In the dynamic section, the fibre optics shall be reinforced with steel armouring or braiding.

7.6.5 Thermoplastic hoses design

Thermoplastic hoses shall be designed as per [ISO 13628-5](#).

Thermoplastic hoses design shall meet the requirements specified as per section 6 of the present specification. Thermoplastic hoses shall be capable of continuous operation in seawater in the conditions specified in section 6.

7.6.6 Steel tubes design

Steel tubes design shall meet the requirements specified as per section 6 of the present specification. Steel tubes shall be capable of continuous operation in seawater in the conditions specified in section 6.

This specification covers mainly Super duplex steel tubes, due to its extensive use for umbilicals. Other steel materials may be considered. In that case, design, qualification, manufacture and testing shall be documented and subject to COMPANY approval.

7.6.6.1 Super duplex tubes

Material requirements

Tubes shall be seamless Super Duplex 25% Cr, manufactured according to [ASTM A789/A789M](#).

Material grade shall be submitted to COMPANY for Approval.

The selection of the manufacturer of stainless steel pipes and fittings shall be subject to COMPANY approval.

Metallurgy requirement shall apply all along the line path including connectors, etc...

Temperature issues

Super Duplex is sensitive to temperature. Mechanical properties derating (Yield stress, Ultimate Tensile Strength, Elasticity modulus, etc ...) shall be evaluated.

Sigma phase issues

Super Duplex is highly sensitive to sigma phase formation during manufacturing process or welding operation. This shall be duly controlled in order to prevent from sensitisation to hydrogen embrittlement.

The integrity of the equipment with regard to such a risk shall be guaranteed.

A Time-Temperature-Phase diagram for the annealing furnace shall be submitted.

Weld procedures for all welds performed during the manufacture and test of the tubing shall be provided.

Maximum allowed sigma phase content: 0.5%. Control procedure shall be defined and submitted to COMPANY for approval.

Corrosion issues

Minimum material PREn or PREw: 41.5 with:

$$PREn = (\% Cr) + 3.3x(\% Mo) + 16 x (\% N)$$

$$PREw = (\% Cr) + 3.3x(\% Mo + 0.5 \% W) + 16 x (\% N)$$

The following shall be detailed: the chemistry and metallurgy, and how the different manufacturing parameters shall be controlled to ensure that the final product microstructure is acceptable.

The critical crevice and pitting temperatures shall be in excess of the design. Critical pitting and crevice temperatures shall be documented and approved by COMPANY.

All the lines shall be compatible with the transported fluids. Corrosion effect shall be considered from transported fluid and from other piping fluids in case of leakage.

In case different tube material grades are used, it is prohibited under any circumstances to mix grades within an individual line on a reel or within an umbilical. This applies as well if materials are from different sources.

Super duplex is sensitive to crevice corrosion in seawater; such a risk shall be considered in respect of operating conditions, and especially seawater temperature.

7.6.6.2 Tube coating

The tubes shall be coated to satisfy the following criteria: preventing abrasion, reducing friction and corrosion.

Super Duplex tubes shall be coated if one of the following conditions is met:

- When tubes can be subject to metal / metal contact. In that case, coating may be also be replaced by shaped fillers or shelves. Metal / metal contact may be accepted for static umbilicals.
- When surrounding seawater design temperature is above 30°C to prevent from potential crevice corrosion issues (the effect of the internal fluid temperature shall also be taken into account)
- In the dynamic part, when carbon steel components are present in the umbilical

The proposed coating shall be subject to COMPANY approval.

The proposed material shall be documented and approved by COMPANY.

7.6.7 Cleanliness

At the umbilical delivery, hydraulic tubes shall meet the cleanliness requirements specified in **GS SPS 023**. Other tubes shall meet the cleanliness requirements specified in the PPS.

Cleanliness shall be maintained in the lines during transportation and installation. The way it is achieved shall be described.

7.6.8 Strength / weight components

Strength / weight components may be added in the umbilical to provide mechanical strength, weight for stability or dynamic behaviour. These may be: armouring, steel rods, steel ropes.

Galvanised steel armouring shall be designed according to **BS EN 10257-2**. Armouring layers shall be separated from the inner bundle by an extruded sheath.

Steel rods and steel ropes shall be coated. The proposed coating shall be subject to COMPANY approval.

7.6.9 Fillers

Fillers material shall be compatible with other components of the umbilical, compatible with the fluids and suitable for subsea use under the service conditions during the design life.

7.6.10 Polymer sheathes

Sheathes can be made by extrusion or roving.

7.7 Ancillary equipment design

7.7.1 Bend stiffener

Repairs are not allowed at any stage during the manufacturing of the bend stiffener.

7.7.2 Pull-in head

The umbilical pull-in head will allow safe pulling of the umbilical and provide the interface with the termination head. The pull-in feasibility through the I-tube shall be demonstrated.

7.7.3 Topside hang-off and termination interface

The termination head shall fulfil, as a minimum, the following functions:

- Termination of all umbilical components.
- Connection of all umbilical functional components
- Transfer of the umbilical loads to the hang-off support. The termination shall ensure that all loads carried by each component are transferred to the hang-off support.

7.7.4 Subsea umbilical termination interface

7.7.4.1 Characteristics

The termination interface shall fulfil, as a minimum, the following functions:

- Termination of all umbilical components
- Connection of all umbilical functional components
- Transfer of the umbilical installation and in-place loads to the SUT
- Interface for bending restrictor

The SUT interface shall be equipped with bending restrictors to prevent over-bending and kinking of the umbilical during handling and installation. The SUT interface shall be cathodically protected.

7.7.4.2 Electrical cables termination water tightness

At every subsea end, prior to be soldered in a connector pin, the electrical wires shall have as a minimum two levels of tight water-blocking, each of them being subject to COMPANY review and approval:

- At the wire level, a tight water-blocking device shall prevent water ingress into the rear part of the connector, in case of wire sheath damage.
- At the cable level, a tight water-blocking device shall prevent water ingress into the individual wires in case of cable damage

7.7.5 Bend restrictors

The locking radius shall as a minimum, the MBR of the umbilical in operation.

The choice of material shall be made based on its ability to sustain loads and its limited degradation due to ageing.

If made of steel, bend restrictors shall be cathodically protected.

7.7.6 Repair kit

Repair kit and associated repair procedures shall be fully qualified and subject to COMPANY approval.

7.8 Cathodic protection

Continuity shall be ensured between the tubes, armours, steel members, connectors and to the CP system. The umbilical and its ancillary equipments (terminations, J-tube...) shall be designed to be cathodically self protected for the design life, in seawater.

Tubes shall be connected to the CP system:

- Topside, the electrical continuity shall be ensured between the tube and steel members of the umbilical, and with the topside termination, in order to connect the umbilical to the platform CP system
- Subsea, electrical continuity shall be ensured between each tube and the termination interface flange, in order to connect the umbilical to the manifold / wellhead CP system.

Possible signal interference and corrosion between different materials in the umbilical (e.g. carbon steel and Super Duplex steel) shall be addressed.

8. Qualification program

8.1 General

Any deviation from a field proven solution shall be verified by a qualification program.

Unless authorized by COMPANY, all qualification program shall be successfully completed prior to the start of the manufacturing phase.

Test failures shall be documented and reported to COMPANY. Failure to meet any of the specified requirements shall require modification of some or all of the design criteria, or the re-test of the design. In the event of a re-test, the reason for the failure of the failed sample shall be included as part of the supporting test documentation. The test in which the sample failed shall be repeated satisfactorily for three new samples before the design is verified except the tests including a complete umbilical. In the event of any redesign of the functional component as a result of a failure, the verification tests shall be repeated in full for the new design before the design can be verified.

Test report shall be reviewed by Company to determine whether the design is acceptable and what steps need to be introduced to mitigate any potential problems that may arise when the umbilical is put into service.

The cross-section to be manufactured shall be qualified according to [ISO-13628-5](#) and with additional requirements detailed in this section, if they are found not to be in compliance with the field proven definition.

No extrapolation shall be made on the validity of a cross-section design, without COMPANY approval.

Fatigue and bending stiffness qualification tests on static sections are not required if fatigue calculations demonstrate clearly that contingencies allow for recovery of all static section during installation and sensitivity analyses have been performed during detail engineering on the bending stiffness parameter .

In all cases, the qualification programs, including test specifications and procedures with acceptance criteria, shall be submitted to COMPANY for approval prior to the implementation of the components, materials or technologies in the design.

The resulting qualification reports, reproducing the original qualification program together with the achieved results, shall be issued to COMPANY as part of the final documentation.

8.2 Samples

Samples for qualification purposes shall be manufactured ahead of the final production, in the same conditions, according to the same manufacturing and welding procedures and with the same level of equipment as the final production.

Lengths to be manufactured shall be decided during detail engineering and submitted to COMPANY for approval.

A contingency plan that can take into account redesign and qualification test failure shall be provided.

The length of umbilical shall be manufactured, as prototype for qualification testing as per [ISO 13628-5](#) §10.2.

8.3 Qualification procedure

A Quality Plan shall be in effect and agreed upon prior to any phase of the qualification.

COMPANY requires acceptance criteria for all qualification tests. A complete document shall be issued to COMPANY prior to any qualification test, including:

- Objective
- Methodology and qualification principle
- Detail program
- Means
- Deliverables
- Acceptance criteria

For qualification test that are not prone to an acceptance criteria, a tolerance criteria to which the result of the test shall comply shall be defined.

For test results that may not fall within the tolerance range, the deviation shall be justified and the results be submitted to COMPANY for approval.

8.4 Qualifications requirements

All tests shall be performed according to the [ISO 13628-5](#).

For the tests that are not covered by the standard, i.e. tensile test of all auxiliary equipment that may have to withstand a tensile load, this shall be done at 1.5 times the maximum installation or operational tension, whichever is the highest.

As a general rule, all tests shall be carried out at the maximum design values. Deviations from these maximum design values are to be approved by COMPANY.

During all qualification tests, continuous monitoring of electrical cables insulation resistance or capacitance shall be performed.

Electrical test measuring procedures shall be reviewed and approved by COMPANY prior to any test being performed.

Qualification tests on individual components are only required if the component have not been qualified previously.

They shall be performed on one sample/ batch or lot. As a minimum all test listed and described here-after shall be performed:

Qualification test requirements:

Test	Description
Full scale fatigue test	ISO 13628-5 & section 8.5
Installation simulation	See section 8.6
Bend stiffness test	ISO 13628-5
Crushing	ISO 13628-5
Tensile test and torsion stability test (including termination interface)	ISO 13628-5

Test	Description
Hang off system	see section 8.7
Free flooding test	see section 8.8
Structural damping	see section 8.9
Individual components (steel tubes)	ISO 13628-5 & section 8.10
Individual components (welds)	ISO 13628-5 & section 8.11
Individual components (electrical cables)	ISO 13628-5 & section 8.12

8.5 Full scale fatigue test

This test shall be conducted in accordance to [ISO 13658-5](#) and following amendments:

All tubes shall be fixed at both ends of the sample, i.e. not allowed to move one relative to the other.

The length of the sample shall be minimum 2 pitch length of the most fatigue sensitive tubes in the umbilical.

Tension in the umbilical shall simulate the actual dynamic umbilical mean tension.

8.6 Installation simulation test

The purpose of this test is to demonstrate the suitability of the installation method and parameters with the umbilical.

This test shall be performed with the caterpillars similar to the ones used for the actual installation. The maximum installation tension including the contingency cases shall be applied to the umbilical.

A test at maximum crushing pressure including contingency cases shall be conducted to confirm that the internal components are not damaged

The set up of the umbilical within the caterpillars shall be such that the cables are located in a zone where crushing will be maximum.

It shall be checked as minimum the following:

- No sliding of the umbilical
- Clamping force sufficient to transfer the load to the tubes
- No crushing of the tubes
- No damage of the electric cables

8.7 Hang-off test

The purpose of this test is to confirm that the anchoring of components (tubes, cables...) at the surface facility termination can withstand the design maximum load. The load shall be 1.5 times the maximum load in service or installation.

This test shall confirm the suitability of the system for the design life, i.e. including ageing and vibrations.

This test can be combined with tensile test from [ISO-13628-5](#).

8.8 Free flooding test

The purpose of this test is to ensure that the manufactured umbilical will be completely flooded when laid on seabed, i.e. confirm free flooding flow through umbilical section representative of laying speed.

This test can be avoided if roving is used on the static sections and no intermediate sheath can restrict water ingress inside the umbilical.

8.9 Structural damping

This test shall be performed for dynamic umbilicals, except if the VIV analyses in the design have been performed satisfactorily with a structural damping factor of 0,0. The objective of the test is to measure and validate the structural damping factor used in the analyses.

The test procedure shall be submitted to COMPANY for approval.

8.10 Steel tubes

The following tests shall be performed in addition to [ISO 13628-5](#) requirements

- Pre-strained tube mechanical properties (see section 8.10.1)
- Ferrite content (see section 8.10.2) for Super Duplex tubes
- Tensile test at ambient temperature and 70°C according to [ASTM A370 & ASTM A789](#)
- Compatibility with umbilical fluid
- Burst test sample (2 times the design pressure)

8.10.1 Tubes mechanical properties

A test shall be carried out on each tube size to be used in the umbilical where the tube is pre-strained to minimum 15%, and mechanical properties of material tested.

The purpose of this test is to verify the effect of strain such as strain hardening and Baushinger effect.

8.10.2 Ferrite content test

This section only applies to Super Duplex tubes.

The ferrite content test shall be based on [ASTM E562](#) with content within the range 35% - 55%. The duplex structure is to be homogeneously distributed.

8.11 Welds qualification

For super Duplex tubes, welds shall be qualified according to [GS PVV 614](#) with the following deviations:

Section 6.2: Stamping of welder or welding operator identification number is not required, but full traceability (welder identification to weld number) shall be achieved during production.

Section 4.1: Use of nitrogen instead of argon as backing gas is acceptable provided that the same "system" (flow rate, purge arrangement and set-up) is used during welding procedure qualification test and production

8.12 Electrical cables

Qualification tests to be conducted on cable samples of suitable length, shall clearly demonstrate that electrical properties checked will not be affected by an external pressure corresponding to the project water depth, unless previous qualification tests at the required water depth, for the same cable design, are available and acceptable by COMPANY.

Qualification of the individual cores shall be performed as per [ISO 13628-5](#).

ISO amendments about the external pressure test are subject to COMPANY approval and shall be documented with a detailed comparison between the ISO tests and their proposal (with qualification tests if needed). A detailed test procedure shall be written and shall be submitted to COMPANY approval before the cable contract award.

8.13 Repair procedure qualification

Repair procedure qualification shall be performed according to [ISO 13628-5](#) section 15.23.

9. Manufacturing and testing

Manufacturing and testing of umbilicals shall be performed according to [ISO 13628-5](#) requirements.

This section defines additional requirements to be satisfied.

Prior to start of the manufacturing activities a manufacturing kick-off meeting shall be organised.

9.1 Quality Assurance Requirements

9.1.1 General

The quality assurance system shall be [ISO 9001](#) compliant and shall be certified. The Certifying Authority reports and conclusions shall be issued to COMPANY.

It shall be demonstrated that Prime References quality assurance requirements are fully satisfied.

COMPANY is concerned by potential deviations between the characteristics of the umbilical and its components used in the design and the final product resulting from the manufacturing process. At all levels of the manufacturing process, clear evidence of the compliance of components, intermediate and final product to the design parameters shall be produced. Corrective measures shall be undertaken in case of deviation from the design parameters.

9.1.2 Documentation

9.1.2.1 Procurement Plan

Based on the overall delivery schedule, a procurement plan shall be prepared for all materials required including specific equipment for testing.

The procurement activities shall be co-ordinated and corrective actions initiated in order to ensure that the requirements of the procurement plan are met.

During the procurement phase, a progress report shall be issued on a regular basis, with particular emphasis on performance of quality control and acceptance testing.

9.1.2.2 Manufacturing Quality Plan

The Manufacturing Quality Plan (MQP) shall contain as a minimum:

- Detailed fabrication and assembly procedures, including a step by step description of the fabrication process, working procedures and repair procedures to be used during the fabrication and assembly of the umbilical lengths and associated termination parts
- A Control Inspection Plan, defining all inspections, verifications and controls to be carried out during the fabrication and assembly phases, together with references to the relevant documents containing the associated acceptance criteria
- A Factory Acceptance Testing (FAT) Procedure, defining all tests to be carried out during the fabrication and assembly phases

Witness and hold points during fabrication shall be indicated.

The MQP shall be submitted for review, comments and approval by the COMPANY.

All specific requirements indicated in the sections below shall be included in the MQP and identified by the code "Client Requirements".

A progress report of the manufactured umbilicals shall be issued on a weekly basis.

9.1.3 Certifying Authority

Independent verification agent approved by Company Certifying Authority shall witness and shall certify the manufacturing of the umbilical.

9.1.4 Storage

Detailed storage instructions shall be provided taking into account the nature of the goods and their vulnerability to high or low temperatures, dust, impact, moisture, light (sunlight), corrosion, oxidation, magnetism, theft, etc.

The Manufacturer shall be fully responsible for the proper organisation of his warehouses and stocks, including clear, unambiguous marking of the goods for their identification and location.

More generally, all equipment forming part of the final delivery, as well as any component thereof, shall remain the full responsibility of the Manufacturer until the complete job has been delivered and accepted.

9.1.5 Traceability

Throughout the fabrication and assembly process, all components shall be clearly identified and marked with a unique reference code, which must be quoted in all associated documentation.

For umbilical lengths, a proper identification system shall be implemented, to ensure that the umbilical, and section if relevant, can be quickly identified at any time during the fabrication process.

9.1.6 Control and Inspection

The fabrication and assembly controls and inspections shall be performed in accordance with the Control Inspection Plan approved by COMPANY. COMPANY shall be granted unrestricted access to the fabrication, assembly and/or testing sites, as well as to all documentation and control/inspection data.

To ensure quality and dimensional tolerances (diameter, thickness, length), the following minimum inspections shall be performed:

- Continuous measurement of diameters during all stages of fabrication: if continuous measurement is not possible, the umbilical diameter shall be checked every 10 meters and at shorter intervals in the event of problems or at any COMPANY representative's request.
- During the fabrication phase, the entire length of the various umbilicals shall be monitored with an indication and record of any particular points or repairs.

Length tolerance for umbilicals shall not exceed $-0.0/+1.0$ % of the required overall length as previously determined. No negative tolerance shall be accepted.

9.2 Manufacturing Process Requirements

9.2.1 Steel tubes

The supplier shall at all times ensure that no contact of the hollows and tubes with any material leading to contamination such as carbon steel, copper... in order to prevent parent corrosion.

The tubes shall be received in one continuous length on a reel from the tube supplier ready for coating or lay-up. A proof test shall be performed at umbilical supplier's facility upon receipt of each batch of tubes.

The tubes shall be delivered at Umbilical manufacturing site on reels protected by wooden battens in order to protect the tubes against external aggressions.

The welding of the tubes from straight length may be performed in Umbilical manufacturing site if approved by COMPANY.

Welding, inspection and testing procedures, including acceptance criteria related to the tubes manufacturing and welding shall be submitted to COMPANY for approval.

The following tests shall be performed for each batch/lot, in addition to [ISO 13628-5](#) requirements:

- Tube mechanical properties (for Super Duplex tubes, see section 9.2.1.1)
- Corrosion test (for Super Duplex tubes, see section 9.2.1.2)
- Sigma phase test (for Super Duplex tubes, see section 9.2.1.3)

During detailed design phase, detailed test procedures shall be provided.

Full traceability of each tube shall be provided to COMPANY. This includes, but shall not be limited to:

- Material
- Manufacturing process main parameters, e.g. cooling rate to avoid sigma phase formation in Super Duplex tubes
- Welding inspection
- Weld repairs
- Reel used for spooling after welding

9.2.1.1 Tube mechanical properties

This section only applies to Super Duplex tubes.

The mechanical properties of the tubing, to be determined on each batch/lot, are as follows:

- Proof strength (SMYS 0.2% offset), according to [ASTM A789M](#): Min 550 MPa
- Ultimate tensile strength (UTS), according to [ASTM A789M](#): Min 750 MPa
- Elongation (minimum 25% in 2" or 50mm)
- SMYS/UTS $\leq$ 0.85
- Hardness target figure 29 HRC, acceptance criteria: 32 HRC taken 1mm from both internal and external surfaces or at pipe wall centre line if wall thickness below 2 mm.
- Flattening test (minimum expansion of the ID is 10% using 60° cone)
- Surface roughness (maximum 1.6 μ m)

9.2.1.2 Corrosion test

This section only applies to Super Duplex tubes.

Corrosion testing will be performed on once per batch/lot in accordance with [ASTM G48](#) Method A at a minimum temperature of 50°C for the base metal and 40°C for the weld metal. The acceptance criterion is no visible signs of corrosion.

Additionally, a Strauss Test according to [ASTM A262E](#) shall be performed on a tube at the beginning, middle and end of each batch/lot.

9.2.1.3 Sigma phase test

This section only applies to Super Duplex tubes.

Levels of sigma phase shall be proven to be less than 0.5% by metallographic examination. The calibration sample for the in-line eddy current NDT shall contain no more than 2.0% for all tubing sizes.

Sigma phase shall be controlled on regular basis by destructive tests. Test frequency to be accepted by COMPANY.

9.2.2 Tubes welding

This section only applies to Super Duplex tubes.

Welding of stainless steel pipes and fittings shall be in accordance with the relevant COMPANY General Standards document: [GS PVV 614](#)

Tubing manufacturer and umbilical supplier shall prepare and qualify their welding procedure and weldability related to the material, size and wall thickness combinations of the tubes included in the umbilicals.

All welds shall be performed by orbital automatic GTAW (Gas Tungsten Arc Welding).

Welding procedures shall be possible to be made at the umbilical manufacturer facility using manufacturer welding machines maintaining the welding parameters to the accuracy required.

Welding procedures at the umbilical manufacturer's site shall be demonstrated prior to approval of tubes production.

After welding, continuous X-ray inspection performed by level II minimum inspectors according to [EN 473](#) shall be performed. If a weld is found to be defective, it shall be cut-out (no repair allowed) taking into account accumulated strain limitations. An independent review of the welds by Level III inspectors according to [EN 473](#) is required on all welds and shall be completed prior to start of next manufacturing step: over sheathing of the tube or lay-up.

If a weld defect is found prior to over sheathing or lay-up, the weld shall be cut and a new weld performed prior to over sheathing. It shall be justified that the additional spooling operation will not cause the APS criteria to be exceeded.

The dynamic section shall be manufactured without any tie-in weld, i.e. the length of tube on the lay-up reels will be sufficient to manufacture one complete umbilical dynamic section.

9.2.3 Strain control during manufacturing

Plastic strain imposed on the tubes of the umbilicals shall need COMPANY approval prior to manufacturing.

The manufacturing process shall take it into account. The following general rules shall be applied:

- Limitation of number of spooling
- Spooling of tubes on as large as possible drum reels
- Reels for lay-up machine with as large as possible drums
- Use of carousels during manufacturing as much as possible
- If tubes are coated, spooling of tubes after welding shall be done on as large as possible reels that can be different from the reels to be fitted on the lay-up machine.

9.2.4 Tubes coating / profiles

The following concerning tube over-sheathing or polymer profiles shall be documented :

- Material
- Tube preparation
- Size of reels used for spooling the tube
- Temperature limitations: e.g. if at low temperature the coating / profiles crack. The chosen material shall be compatible with manufacturing, storage, installation and in place conditions.
- Inspection process for defect of coating or profiles arrangement
- Repair procedure

No defect is accepted on the tube.

Coating repair procedure shall take into account the accumulated plastic strain limitations.

9.2.5 Thermoplastic hoses

Thermoplastic hoses shall be manufactured according to [ISO 13628-5](#).

9.2.6 Electrical cables

During manufacturing phases, special care will be taken to the cleanliness of extrusion machines in order to avoid metallic particles to pollute the dielectric material.

No repair or splice shall be permitted in dynamic section. Depending on the umbilical length, splices may be performed on electrical cables in static section, and shall be subject to COMPANY approval. Any repair that may be performed shall be subject to COMPANY approval. Repair procedure shall be submitted.

9.2.7 Extruded polymer sheathes

Mylar tape or equivalent shall be wrapped around the inner bundle before extrusion to prevent from penetration or melting with components during manufacture.

9.3 Delivery

9.3.1 Documentation

Each delivery shall be accompanied by a document containing all necessary information, such as:

- type and number of reels / carousels,
- length of umbilical on each reel / carousel,
- terminations, bend restrictors mounted on each reel / carousel,
- weight of each reel / carousel,
- factory acceptance tests, etc.

9.3.2 Marking

This section lists marking requirements in addition to [ISO13-628-5](#).

At the extremities all tubes shall be marked to indicate as a minimum:

- Service
- Design pressure
- Manufacturing batch
- Connectors shall be colour coded

All cables shall be individually marked according to section 7.6.3.1

Each umbilical shall be identified with length markings.

Markings shall be in paint that shall have a composition compatible with the external sheath, with good adherence and anti-fouling properties.

9.3.3 Length markings

One marking band shall be painted around the pipe every 10 m. Marking shall be visible in seawater during the design life of the umbilical.

For every 50 m, the number of tens shall be painted, then the number of hundreds and thousands.

9.3.4 Packaging

The umbilicals and ancillary equipments (except equipments mounted topside, i.e. bending stiffener connector female part and topside hydraulic jumpers) shall be made available at Umbilical Supplier's facility ready for load out onto installation or transport vessel in the following conditions:

- Packed onto the installation reels or ready for load out onto installation or transport vessel carousel
- Terminations, bend restrictors mounted
- Testing completed including pre-load out test as per [ISO-13628-5](#)
- Tubes filled with required fluids and cleanliness level and pressurized
- Umbilicals equipped with monitoring equipment

The reel characteristics shall be in accordance with the laying requirements.

On each side of the reels, an identification plate shall indicate:

- Place and country of delivery
- Job name
- Line name or code
- Reel number/Total number of reels for the job
- Customer name
- Contract reference
- Diameter and length
- Net and gross weights.

All additional equipment shall be adequately protected and properly boxed for delivery. All boxes shall be properly identified (see above list of indications), and a boxing list shall be provided.

Accessories and spare parts shall be delivered together with the associated umbilicals.

10. Testing requirements

Testing shall be performed according to [ISO 13628-5](#) unless stated otherwise

10.1 Tests on individual components

The following tests shall be performed prior to integration of the components in the umbilical:

Steel Tubes:

- Welds shall be executed by qualified personnel, according to international procedures accepted by COMPANY, and 100% NDT tested
- Visual inspection
- Dimensional checks (outer diameter, wall thickness, inner diameter, concentricity)
- Burst pressure on samples only according to [ISO 13628-5](#)

- Hydraulic proof pressure test at 1.25 times the design pressure, 60 minutes hold period
- Flushing / Cleanliness

Electric Cables:

- Hydrostatic testing of insulated conductors
- DC conductor resistance. Measurements shall be corrected for temperature and referred to 20°C. The accuracy of the conductor resistance measurements shall be in milliohm. Temperature correction and accepted criteria shall be in accordance with [IEC 60228](#).
- Insulation Resistance: Insulation resistance: shall be measured between conductors in the same pair or quad, between each conductor and the corresponding shield, between shields and electrical cable armour, if any.
- High voltage DC
- Time domain reflectometry (No splice is accepted)
- Attenuation characteristics within the communication frequency band
- Inductance
- Capacitance
- Characteristic impedance
- Near end and far end cross talk
- Spark test

Tests procedures shall be submitted to COMPANY.

10.2 Tests on completed umbilical prior to integration of the termination interfaces

These tests shall be conducted in order to prove that the finished umbilicals are ready to receive the extremities. A complete test program shall be proposed, including, but not limited to:

- Complete electrical characteristics of the cables as per [ISO 13628-5](#)
- Proof pressure test of the tubes at 1.25 times the design pressure.
- Cleanliness verification of the hydraulic tubes

10.3 Factory Acceptance Tests (FAT)

FAT of completed umbilicals shall be performed according to [ISO 13628-5](#) requirements and shall include, as a minimum, for each umbilical the following program:

Complete umbilical:

- Visual and dimensional
- Cleanliness according to [GS SPS 023](#) and [AS 4059](#)

SUT & terminations interfaces:

- Water tightness of electrical cables soldering to SUT electrical distribution box at 1.25 x hydrostatic pressure
- Cathodic protection continuity between metallic components and SUT or termination

At the issue of the FAT, a complete dossier gathering all tests reports shall be released to COMPANY.

10.4 Test of umbilical prior to installation

In case of umbilicals to be made available on the lay barge, on carrousels or reels, a complete test program, to be performed on-shore, shall be submitted to COMPANY for approval, prior to any load out work. The following tests shall be carried out, as a minimum, on every umbilical:

- Visual inspection
- Pressure test of every steel tube: a test procedure shall be proposed and shall include, as a minimum, 15 minutes at the working pressure without flow and/or loss of pressure
- Measurement of cleanliness of every tube. For the hydraulic lines, only the hydraulic control fluid shall be used for this measurement
- For every electrical cable, insulation resistance between conductors, between conductors and shield, and between shield and armour. This test shall include the connectors at the extremities
- For every electrical cable, resistance of every conductor and every shield. This test shall include the connectors at the extremities

10.5 Auxiliary equipment test

10.5.1 Bending stiffener connector

Prior to being delivered to the FPSO, all male parts shall be tested for interface with all female parts to avoid any pairing requirement.

10.5.2 Bending restrictor

One set of element of each type or batch depending on manufacturing process of bending restrictor shall be load tested to confirm max design bending moment capacity.

10.5.3 Bending stiffener mock-up test

A mock-up test shall be performed to demonstrate that no pairing of the bending stiffener connector is required, i.e. all male parts shall be trial fitted with dummy female parts extreme tolerances, or tested with all actual female parts.

11. Project particular specification

The objective of this section is to provide a guidance for writing a COMPANY Project Particular Specification (PPS). The document should be made as follows:

11.1 Design data

Design data shall be provided according to section 6.

Umbilical characteristics should be defined by the control system supplier, clarified and verified by the umbilical supplier.

11.2 Design requirements

The following shall be specified by COMPANY:

- Additional specific design load cases, if required (section 7.2)
- Safety class according to [DNV OS F201](#) / [DNV OS F 101](#) (section 7.3)
- Studies to be performed: for static umbilicals, some studies may not be required (section 7.5)
- Tubes material: thermoplastic, super duplex, or other, in respect of the fluid and seawater environment compatibility. Guidance is provided in Appendix 2 (section 7.6)
- Free flooding: may be required for deep water applications (section 7.6)
- Steel tube coating: for high temperature applications, the coating shall be performed according to [GS COR 100](#), [GS COR 201](#) and [GS COR 350](#) (section 7.6)
- Topside: hang-off and termination, pull-in head, functional and mechanical interfaces, J-tube inside diameter, electrical and hydraulic connections, jumpers (section 7.7)
- Subsea: SUT, SDU, functional and mechanical interfaces, electrical and hydraulic connections, jumpers, with associated acceptable loads (section 7.7)
- The water tightness philosophy shall be assessed, depending on the level of criticality, availability of the umbilical, which is governed by operational philosophy (section 7.7)

11.3 Qualifications

Full scale fatigue testing: the conditions shall be defined in adequation with the actual configuration of the umbilical (section 8.5).

- For dynamic control umbilicals, the test should be performed with the bend stiffener, simulating hang-off loading. Additional test may be required if other fatigue area are foreseen (arch region, TDP, ...)
- For work-over umbilicals, the test should be performed with an oscillating sheave simulating the drilling rig winch

Tubes fatigue test may be required for specific tubes sizes if no fatigue data are available.

Appendix 1 Umbilical data sheet

Data sheet to be provided to COMPANY

For each umbilical, the following data shall be provided, in SI units.

Umbilical general data

	Unit
Cross section drawing including dimensions in and tolerances	
Umbilical outside diameter	mm
Weight in air empty	Kg/m
Weight in air fluid filled	Kg/m
Weight in air fluid filled and flooded	Kg/m
Weight in water empty	Kgf/m
Weight in water fluid filled	Kgf/m
Weight in water fluid filled and flooded	Kgf/m
Diameter to submerged weight ratio	m ² /kgf
Maximum allowable load under tension (no bending)	kN
Minimum breaking load under tension (no bending)	kN
Maximum allowable crushing load	kN/m
Axial stiffness	kN
Bending stiffness at 20°C and 4°C	kN.m ²
Torsion stiffness	kN.m ²
Minimum bending radius for storage, handling (with associated plastic strain and tension load)	m
Minimum bending radius for installation (with associated plastic strain and tension load)	m
Minimum bending radius for operation (with associated tension load)	m
Minimum bending radius (at elastic limit, with no tension load)	m

Tubes data

Material characteristics	Material	
	Young's modulus	MPa
	Specified minimum yield strength	MPa
	Tensile strength	MPa
	Thermal expansion	1/°c
	Poisson's ratio	
Size	Inside diameter	mm
	Number off	
	Nominal wall thickness	mm
	Design pressure	bar

Electrical cables data

Construction	Type	
	Number off	
	Conductor size and number of strands (cross sectional area)	mm ²
	Conductor material	
	Conductor insulation material	
	Cable outer sheath material	
	Shield	
	Braiding	
Electrical characteristics	Voltage rating	kV
	Loop resistance	Ω/km
	Capacitance	nF/km
	Inductance	mH/km
	Conductance	μS/km
	Attenuation	dB/km
	Cross talk	dB
	Insulation resistance	MΩ.km



Fiber optics data

Construction	Type	
	Number off	
	Size	
Characteristics	Mode	
	Wavelength	nm
	Attenuation	dB/km

Strength/weight component data

Type	Rod / wire / armour	
Material characteristics	Material	
	Young's modulus	MPa
	Specified minimum yield strength	MPa
	Tensile strength	MPa
	Thermal expansion	1/°c
Size	Outside diameter	mm
	Number off	

Fillers

Type	
Material	

Extruded sheathes

Type	
Material	

Appendix 2 Guidance for tube material selection

The table presented below only intends to give indications for the selection of tubes material. The compatibility with fluids shall be demonstrated in any case.

Material Function	Thermoplastic hose	Super Duplex tube	Carbon steel tube
Hydraulic	YES	YES	NO (2)
Methanol service	NO (1)	YES	YES
Chemical	YES	YES	YES (3)

- (1) Methanol permeation
- (2) Cleanliness level not reached due to possible circulation of corroded particles inducing damages on subsea equipment (valves ...)
- (3) The corrosion resistance has to be checked with the fluid

Appendix 3 Fatigue curve for Super Duplex welded tubes

For fatigue design of small diameter pipe umbilicals made of super duplex steel with a yield strength larger than 500 MPa with thicknesses in the range 1.0 to 10 mm the following S-N curve can be used for fatigue assessment

$$\text{Log}N = 14.319 - 3.5 \cdot \text{Log} \left[S \cdot \left(\frac{t}{t_{ref}} \right)^{0.25} \right] \text{ for } N \leq 10^7$$

$$\text{Log}N = 17.456 - 5.0 \cdot \text{Log} \left[S \cdot \left(\frac{t}{t_{ref}} \right)^{0.25} \right] \text{ for } N \geq 10^7$$

where

t = actual thickness of the umbilical

t_{ref} = 1.0 mm

S = Alternating stress

This curve is applicable for welded super duplex tubes and does not take into account the following:

- Pre-straining cycles during manufacture
- Seawater environment in operation without cathodic protection
- Temperature effects
- Mean stress correction