

GENERAL SPECIFICATION

PIPELINES - RISERS

GS EP PLR 160

Design, fabrication and testing of Subsea Umbilicals

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08	10/2016	General revision
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1. Scope

This General Specification is applicable to the design, procurement, manufacturing, testing, load out, and transportation of subsea electrical cables and umbilicals. The installation is covered by **GS EP PLR 401**.

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.

External Documents

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

Reference	Title
API SPEC 17L1	Specification for Flexible Pipe Ancillary Equipment
API RP 17L 2	Recommended Practice for Flexible Pipe Ancillary Equipment
ASME BPVC Section IX	Welding, Brazing, and Fusing Qualifications
ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A450	Standard Specification for General Requirements for Carbon and Low Alloy Steel Tubes
DNV	Rules for Planning and Execution of Marine Operations
DNV-OS-F101	Submarine pipeline systems
DNV-OS-F201	Dynamic risers
DNV-RP-C203	Fatigue design of offshore steel structures
DNV-RP-C205	Environmental Conditions and Environmental Loads
DNV-RP-F105	Free Spanning Pipelines
DNV-RP-F109	On-Bottom Stability Design of Submarine Pipelines
DNV-RP-F112	Design of duplex stainless steel subsea equipment exposed to cathodic protection
DNV-RP-F203	Riser Interference
EN 10204	Metallic products - Types of inspection documents
EN 10257-2	Zinc or zinc alloy coated non-alloy steel wire for armouring either power cables or telecommunication cables - Part 2: Submarine cables
ISO 13628 (Parts 5; 8)	Petroleum and natural gas industries - Design and operation of subsea production systems - Parts 5; 8

Reference	Title
ISO 4406	Hydraulic Fluid Power - Fluids - Method for Coding the Level of Contamination by Solid Particles
ISO/TS 29001	Sector-specific quality management systems - Requirements for product and service supply organizations
SAE AS 4059E	Cleanliness classification for hydraulic fluids

Total General Specifications

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

Reference	Title
GS EP COR 100	Cathodic protection of offshore structures
GS EP COR 221	Three layer polypropylene external coating for pipelines
GS EP COR 232	Composite/Syntactic foam used for buoyancy modules for permanent subsea applications
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP COR 560	Physical and chemical treatment of hydrostatic test water
GS EP ELE 765	Subsea cables
GS EP PLR 001	Documentation requirements
GS EP PLR 100	Submarine pipeline systems
GS EP PLR 241	Fabrication of Super-Duplex Stainless Steel Small Bore Seamless Tube for Umbilical
GS EP PLR 245	Fabrication of Super Duplex stainless steel Small bore seam welded tubes for umbilical
GS EP PLR 401	Installation of submarine pipelines
GS EP PLR 423	Welding of Super-Duplex Stainless Steel Small Bore Tube for Umbilical
GS EP SPS 002	Design of Subsea Stations
GS EP SPS 009	Corrosion protection of subsea stations
GS EP SPS 019	Subsea production control system
GS EP SPS 021	Subsea mateable electrical/optical connectors
GS EP SPS 029	Metallic Materials for Subsea Production Facilities
GS EP STR 204	Subsea structures: Carbon Steel Material and Fabrication

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Reference	Title
GS EP STR 401	Loadout, seafastening, transportation and installation of offshore structures
GS EP TEL 190	Offshore optical fibres based telecommunications

3. Definitions and abbreviations

Definitions and abbreviations used in this General Specification are in accordance with the [ISO 13628-5](#) except otherwise written. Modifications and additional terms are defined below.

3.1 Definitions

Company	Total
Supplier	The Umbilical supplier
The Design	Means all the studies and engineering tasks to be performed either at a Pre-Project or a Project level as necessary for the Works
The Project	Means the basic engineering, FEED, detailed engineering and construction engineering
The Work	Means the construction of the System , including the site preparation, the precommissioning works, and the site reinstatement works
Particular specification	Any particular specification based on Project requirements and on instructions for the performance of the works. May be also referred as job specification
Accumulated Plastic Strain	Sum of plastic strain from each strain cycle during the process considered (manufacturing, handling, installation)
Dynamic section	Section of umbilical exposed to cyclically varying loads and deflection during normal operation
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
Tie-in weld	Weld between two reels of components (steel tube, steel rod, armouring, etc.) during the lay-up process of the umbilical

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3.2 Nomenclature and abbreviations

APS	Accumulated Plastic Strain
CP	Cathodic protection
EFL	Electrical Flying Leads
FAT	Factory Acceptance Test
FEED	Front End Engineering Design
FMECA	Failure Mode Engineered Critical assessment
FO	Fibre Optic
FPS	Floating Production System
GTAW	Gas Tungsten Arc Welding Process
HFL	Hydraulic Flying Leads
HV	Hardness Vickers
ITP	Inspection and test plan
MQC	Multi Quick Coupling
MQP	Manufacturing Quality Plan
NDT	Non Destructive Test
PPS	Project Particular Specification
QCP	Quality Control Plan
QRA	Quantified Risk Analysis
SMYS	Specified Minimum Yield Stress
SCF	Stress Concentration Factor
SPS	Subsea Production System
SUT	Subsea Umbilical Termination
Sw/OD	Submerged Weight over Outside Diameter ratio
TDP	Touch Down Point
TUT	Topside Umbilical Termination
VIV	Vortex Induced Vibration
WPQ	Weld Process Qualification
WPS	Weld Process Specification

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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 hydraulic and electrical control, communication and power umbilical systems and hydraulic and electrical flying leads.

4.1 Applicability

This specification addresses both static and dynamic application of umbilicals.

This specification applies to subsea control, chemical injection, power, and gas-lift umbilicals and electrical and hydraulics flying leads. Workover umbilicals are not covered by the present specification.

Activities addressed include design, procurement, manufacturing and testing which are summarized as:

- Engineering of the umbilical structure, internal components and its ancillary equipment (end terminations, terminations units, buoyancies, etc.). Engineering of the behavior of the umbilical during installation and in service, including riser dynamic configuration definition.
- 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.

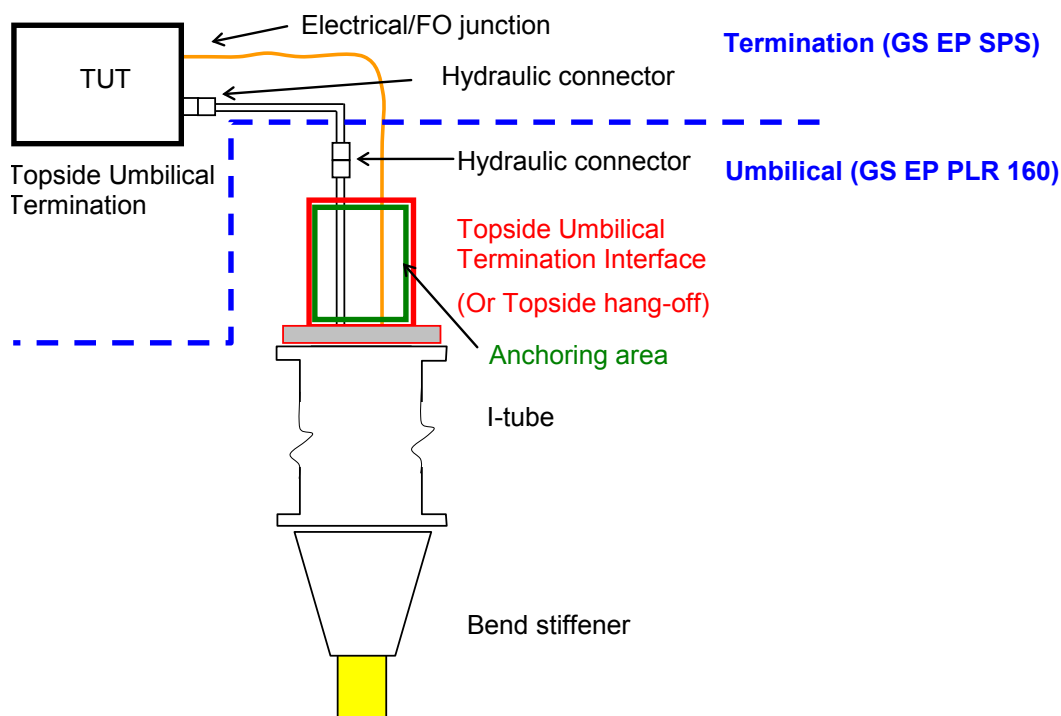
4.2 Interfaces with SPS General Specifications

The present specification applies to the following components of the umbilical system:

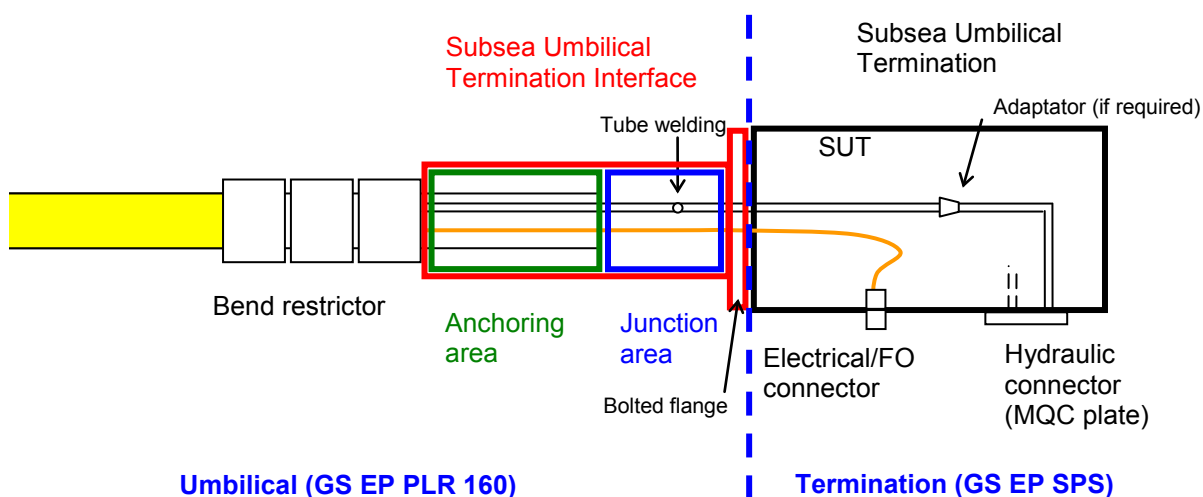
- Umbilical and components
- Topside termination interface (or Topside hang-off)
- Subsea termination interface
- Bend restrictors
- Bend stiffeners
- Pull-in head
- Topside electrical pigtail, hydraulic jumpers, hydraulic connectors
- Subsea electrical pigtail, hydraulic tubes interface welding
- Other ancillary equipment such as buoyancies, stabilization or crossing features, repair joints, I-tube seal, etc.

Topside umbilical termination (TUT), subsea umbilical termination (SUT), subsea electrical connectors and junction boxes, subsea hydraulic connectors are covered by **GS EP SPS 002, GS EP SPS 009, GS EP SPS 019, GS EP SPS 021 & GS EP SPS 029.**

Technical interfaces with above mentioned SPS general specifications shall be considered as follows, if not specifically addressed through the project specifications:



Topside interfaces



Subsea interfaces

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4.3 Basic principles

The design, procurement, manufacturing and testing shall be performed according to the [ISO 13628-5](#), [GS EP PLR 100](#). The [ISO 13628-5](#) shall be considered as the Prime reference for the design, manufacturing and testing for the umbilical.

In addition, this 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 detail. Detailed drawings of the umbilical cross section and ancillary equipment shall be disclosed.

Design documentation shall be provided according to [GS EP PLR 001](#) and this General Specification.

Prior to the start of design activities, a design basis shall be submitted to Company for review and approval.

6. Design data

The information required to design an umbilical is defined in [ISO 13628-5](#) and Appendix 2.

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

7. Design Methodology

In the following sections, when testing is required, it shall be understood that Company may relax this requirement if tests have already been conducted in conditions at least as onerous as the conditions of the project development under consideration. Full details of the test protocol, test results and justification for the validity of the existing tests to cover the project development conditions shall be provided to Company for approval.

7.1 General requirements

The umbilical system shall be designed to withstand the loads induced by manufacturing, transportation, installation, recovery where appropriated, and operation.

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 shall be conducted according to [ISO 13628-5](#) and this General Specification.

Any parameter of the umbilical system which cannot be fully described and ascertained must be determined by an appropriate test campaign.

All ROV interfaces shall be designed according to [ISO 13628-8](#).

7.2 Loads

All analyses and cross section definition shall take into account the loads encountered during the whole cycle life of the umbilical.

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ISO 13628-5 requirements shall be satisfied and in addition, special attention shall be paid to:

- Loads generated during manufacturing and transpooling.
- Effect of buoyancy modules and attachments to the umbilical: local additional weight or buoyancy loads shall be included. Computer models shall represent not only additional weights but shall model hydrodynamic forces. Specific requirement link to design and fabrication of buoyancy modules are defined in **GS EP COR 232**.
- Effect of additional equipment required for the installation.
- Hydrodynamic forces: for each wave and current direction, the phase shall be considered to produce the maximum hydrodynamic horizontal force.

7.3 Analyses

Supplier shall conduct umbilical analyses as per ISO 13628-5 requirements. In addition, the following requirements shall be adhered:

7.3.1 Risk assessment

The risks shall be assessed in measurable terms - such as from QRA - and in the following order of precedence: human, environmental, industrial.

This assessment shall be made for manufacture, installation/recovery and operation phases.

The risks shall be evaluated at the earlier phase of the design and shall be re-evaluated in the course of the design at every occurrence of a significant change in the design conditions. Risk mitigation measures shall be implemented as necessary.

At the end of the design, it shall be demonstrated that both the safety goals and the functional requirements have been successfully reached.

7.3.2 Usage factors and capacity

Capacity curves shall be produced for each cross section (tension vs. curvature for a given internal pressure) for installation and operation phase, with clear indication of limiting component (e.g. tube, electric cable, etc.).

Maximum allowable stress/strain and usage factor for each component (tube, electric cable, strength member, sheath, etc.) in installation, in place hydrotest and operation phase shall be clearly indicated, justified and subject to Company approval.

7.3.3 Structural analysis

Structural analyses of the umbilical shall be conducted in order to provide mechanical characteristics required for the dynamic analyses and to calculate local stresses in components. Particular attention shall be taken at the hang-off, sag bend, TDP and anchoring (if any) area.

As a minimum, the following shall be assessed and justified:

- Loads distribution (tension, bending, torsion) between the components of the umbilical.
- Contact and friction loads between components, as well as the friction model used (clear identification of stick/slip conditions). Sensitivity studies shall be conducted on the friction parameter in order to evaluate the impact on loads generated on components.

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- Load sharing calculation methodology shall be made available for review by Company.

Effect of temperature on component shall be assessed for temperature above 50°C and below -30°C, i.e. mechanical properties de rating, ageing... De rating curve for super duplex mechanical properties proposed in [DNV-OS-F101](#) or in the [DNV-OS-F201](#) could be used if supported by tests data. As a general requirement, any parameter or methodology which is not sufficiently accurately covered by the design tools (see section 8) shall be subject to sensitivity studies.

7.3.4 Global Analysis

A complete Global Analysis shall be performed for dynamic umbilical.

Global Analysis shall include Dynamic, Interference and Fatigue Analysis.

The Global Analysis shall account for three-dimensional dynamic response, stochastic response and non-linear effect.

The Design Basis shall present as a minimum:

- Main design parameters for the Dynamic Analysis, Interference Analysis & Fatigue Analysis
- Load cases; including sensitivity analysis
- Design philosophy
- Methodology to be used
- Software to be used.

The computer model, assumptions and results shall be fully documented.

The Global Analysis study shall provide as a minimum:

- Quick overview of the input data
- Independent tables for all the dynamic, interference & fatigue run for each line
- Main outputs required to properly design the flexible, i.e. tension range, angle range and curvature radius range
- For each dynamic case, stress level in each component
- Utilization ratio for each component
- Cumulated fatigue damage in each component.

7.3.4.1 Dynamic Analysis

The Dynamic Analysis of the umbilical shall be performed using 3D finite element software including environmental loads, i.e. waves, current, floating support motions.

The software selected for the analysis must include the axial, bending and torsion effects.

Load classes and load combinations used for Dynamic Analysis shall be in accordance with the load cases defined and agreed in the Design Basis.

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Sufficient parametric studies shall be performed and documented to check the sensitivity of the analysis results to reasonable variation in input parameters. At least a parametric study on the period, wave heading and drag coefficients selection shall be conducted.

The significant response parameters which are required from Dynamic Analysis have to include the following as a minimum:

- Umbilicals angles at top side
- Maximum and minimum effective tension distribution along the umbilicals
- Maximum and minimum curvature along the umbilicals
- Clearance between umbilicals and adjacent lines or structures
- Angles and tensions at umbilicals extremities to design the bend stiffeners
- Loads at bottom of the I-tubes and at subsea connections.

Marine Growth

The effect of the marine growth shall be taken into account (thickness to be applied on the outer radius) along the umbilical risers in the Global Analysis, including in the buoyant section.

The drag coefficients shall be adjusted accordingly and documented. Recommendations provided in [DNV-RP-C205](#) could be used.

Buoyancy modules

The configuration shall be demonstrated to be acceptable with the following buoyancy cases:

- Initial buoyancy (as manufactured)
- End of life buoyancy (loss of 5% buoyancy on every module / system)
- Loss of 10% of buoyancy.

For hydrodynamic calculation, effect of buoyancy elements shall be assessed as per methodology described in the [DNV-RP-C205](#) section 6.11.

Specific requirement link to design and fabrication of buoyancy modules are defined in [GS EP COR 232](#).

7.3.4.2 Interference Analysis

In any conditions, it is not allowed that umbilical, crosses above or below any other dynamic lines, i.e. flexible, steel risers, umbilicals and mooring lines.

Interference Analysis shall be performed in order to avoid any contact or crossing between umbilicals and other items, i.e. mooring lines, risers, structures, etc.

A no clashing criteria shall be used to provide details for riser arrangement, hang-off angle and azimuth separation angles between adjacent risers.

Interference Analysis shall be performed with a configuration assuming that all lines are installed.

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Shield effect of two adjacent lines shall be evaluated and documented. Effect of the shield may be modeled by adjusting the Cd value based on Huse formulation as presented in Appendix B of the [DNV-RP-F203](#).

Supplier shall define the correct characteristics of the lines, in terms of Sw/OD ratio, stiffness and length, in order to comply with the above requirements.

7.3.4.3 Fatigue Analysis

Detailed fatigue methodology shall be included in the design basis for Company review and approval.

General requirements

The Fatigue Analysis shall be done with the following input:

- Internal Pressure: Max. Operating Pressure
- Temperature of components along the line for temperature above 50°C.

The fatigue contribution of each fatigue loading shall be determined:

- Response to the wave frequency
- Response due to low frequency excitation
- Response due to vortex shedding.

The Fatigue Analysis shall be verified for the following phases:

- Installation with contingencies considered (recovery). Particular attention shall be paid to the vessel laying system and the TDP. Recommended practices to prevent increased fatigue at TDP and overboard chute due to suspending installation operations shall be given.
- In-place operation with intact mooring. Dedicated studies shall be performed for each singular point (hang-off, sag, hog, and TDP) of each dynamic umbilical.
- In-place operation with damaged mooring (1 anchor line broken) for one year. This shall be used to assess anchorage repair and robustness philosophy of umbilical design.

All components of the umbilical, i.e. tubes, electrical cables, armouring, rods and optic fiber shall be verified for fatigue life.

The effect of residual stress and strain due to manufacturing process, mean stress, SCF, internal friction between components, corrosion and temperature shall be taken into account.

The umbilical shall be designed for the specific project service life with a safety factor of 10. This shall include fatigue damages during component manufacture, umbilical fabrication, load-out, transportation, installation, including one recovery and re installation phase, and operation.