

GENERAL SPECIFICATION

PIPELINES - RISERS

GS EP PLR 110

Design, fabrication and testing of submarine bonded flexible pipes

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1. Scope

This General Specification is applicable to the design, procurement, manufacturing, testing and assembly of bonded flexible pipes. The installation is covered by the **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 supplements, is the latest revision published at the effective date of this document.

In case of conflict with listed data, this document shall apply.

Reference	Title
API RP 17B	Recommended Practice for Flexible Pipe
API STD 2RD	Dynamic Risers for Floating Production Systems
API SPEC 17K	Specification for bonded flexible pipe
DNV-RP-B401	Cathodic Protection Design
DNV-RP-C205	Environmental Conditions and Environmental Loads
ISO 13628-10	Petroleum and natural gas industries - Design and operation of subsea production systems - Part 10: Specification for Bonded flexible pipe
ISO 9001	Quality managements systems - Requirements
ISO/TS 29001	Petroleum, petrochemical and natural gas industries - Sector-specific quality management systems - Requirements for product and service supply organizations
GMPHOM	Guide to Manufacturing and Purchasing Hoses for Offshore Moorings 2009

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP COR 100	Cathodic protection of offshore structures
GS EP COR 102	Design of cathodic protection of submarine pipelines by galvanic anodes
GS EP COR 201	Galvanic anodes
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP PLR 001	Documentation requirements
GS EP PLR 002	Organization of the design works
GS EP PLR 100	Submarine pipeline systems
GS EP PLR 227	Carbon Steel Flanges, Branch Outlet Fittings and Forged Components for Pipelines
GS EP PLR 401	Installation of submarine pipelines
GS EP PLR 425	Site welding of carbon steel pipelines (sweet and sour service, onshore and offshore) according to API STD 1104
GS EP PLR 426	Site welding of carbon steel and CRA pipelines (sweet and sour service, onshore and offshore) according to DNV-OS-F101
GS EP SPS 009	Corrosion protection of subsea stations
GS EP SPS 029	Metallic Materials for Subsea Production Facilities
GS EP STR 101	Design of offshore jacket and subsea structures
GS EP STR 201	Materials for offshore steel structures
GS EP STR 301	Fabrication of offshore steel structures
GS EP STR 631	CALM buoy terminals

3. Definitions and abbreviations

3.1 Definitions

Throughout this specification, the following definitions apply:

Bonded Flexible Pipe Flexible pipe where the reinforcement is integrated and bonded to a vulcanized elastomeric material, including end fittings and flanges, typically approximately 12 m long. Also referred as “Pipe”.

End connection Connection between the Flexible line and Surface Facility (e.g. FPSO or OLT).

Flexible line Assembly of several Bonded Flexible Pipes, connected to surface facilities.

Surface facility Means FPSO or OLT.

3.2 Abbreviations

The following technical definitions and abbreviations are used in this document:

CALM	Catenary Anchor Leg Mooring
CBF	Coating Breakdown Factor
COC	Certificate of Conformance
CP	Cathodic Protection
CRA	Corrosion Resistant Alloy
FAT	Factory Acceptance Test
FE	Finite Element
FMECA	Failure Mode Effects and Criticality Analysis
FPSO	Floating Production Storage and Offloading unit
HIC	Hydrogen Induced Cracking
IRC	Independent Review Certificate
MBR	Minimum Bending Radius
MQP	Manufacturing Quality Plan
NCR	Non Conformance Request
OLT	Oil Loading Terminal (also referred as CALM buoy terminal)
OOL	Oil Offloading Line
OLS	Oil Loading System (OOL + OLT)
PLEM	Pipeline End Manifold
PPS	Project Particular Specification
VIV	Vortex Induced Vibration

4. Applicability and limitations

This General Specification covers the minimum requirements, provide recommendations and guidelines as well as select the reference documents for Bonded Flexible Pipe.

4.1 Applicability

This specification applies to submarine Bonded Flexible Pipe for Offloading from FPSO to CALM buoy terminal in deepwater applications, for long term performance without planned replacement. It also applies to submarine hoses for shallow water CALM buoy terminals without planned replacement.

This specification does not apply to floating hoses and submarine hoses for shallow water CALM buoy terminals designed and manufactured under [GMPHOM](#) regulations.

This specification only applies to the transportation of stabilized crude oil.

This specification does not apply to the transportation of production oil, rough or treated gas, injected or treated water, methanol, glycol and cryogenic products.

This specification addresses dynamic applications of bonded flexible pipe only.

Design, procurement, manufacturing and testing activities involve:

- Engineering the flexible pipe structure and its ancillary components. Engineering the behaviour of the flexible pipe during installation and in service, including defining the configuration
- Procuring materials, manufacturing, assembling, inspecting, testing and storing all bonded flexible pipes and associated equipment
- Verifying that all goods and services to be delivered meet the specified requirements, and providing adequate documentation.
- Engineering and implementing Inspection, Maintenance and Repair requirements

General requirements for the design of CALM buoy terminals are stated in [GS EP STR 631](#), which shall be used in the conjunction with the present specification.

4.2 Basic Principle

The design, fabrication and testing shall be performed according to the [API SPEC 17K](#), [GS EP PLR 100](#) and [GS EP PLR 002](#). The [API SPEC 17K](#) shall be considered as the Prime Reference for the design and construction of the bonded flexible pipe.

In addition, this General Specification amends, replace, or supplements various sections of [API SPEC 17K](#).

Alternatively and upon Company approval, [ISO 13628-10](#) can be considered.

5. Design Brief and Deliverables

5.1 Design basis

A design basis, including all the input data shall be submitted to Company for approval prior to commencement of the design phase.

The design basis shall highlight critical analysis parameters, their range of variation and specify the need of sensitivity analyses. Design loads and conditions not provided by Company shall be assessed and presented for Company review and approval.

5.2 Design brief

A design brief document shall be provided, detailing the design methodology and the course of actions to be followed to achieve Company requirements.

The document shall exhibit the way the input data are used into the calculations with the associated modelling assumptions. Design philosophy, calculation methods, selected load

cases and design safety factors shall be explicitly explained and presented for Company review and approval.

5.3 Deliverables

Design documentation shall be provided according to [GS EP PLR 001](#) and [API SPEC 17K](#) requirements.

6. Design data

Guidance for project Particular Specification (PPS) is provided in Appendix 2.

The information required to design a bonded flexible line is defined in the [API SPEC 17K](#) and [GMPHOM](#).

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 requirements

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 stringent as the conditions of the project development under consideration. Qualification dossier, 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 Bonded flexible pipe design Requirements

7.1.1 Bonded Flexible Pipe Datasheet

The following data shall be provided, in accordance with Appendix 1:

- Full description and drawings (layer by layer, body and end fitting)
- Bonded Flexible Pipe dimensional and weight properties
- Bonded Flexible Pipe capacity
- Bonded Flexible Pipe modelling.

These data shall be provided for each different type of Bonded Flexible Pipe:

- Main line
- First off / Reinforced
- With collars for buoyancy modules
- Integrated in decoupling device (if any)
- Any other.

7.1.2 Bonded Flexible Pipe Capacity

Bonded Flexible Pipe capacity shall be provided as per [API SPEC 17K](#) design criteria (Recurrent operation, Extreme operation, dynamic loading (fatigue), abnormal operation, installation, FAT, hydrotest) for:

- Pressure combined with tension / compression, including end cap effect for pressures from 0 barg to site hydrotest pressure
- Allowable tension versus curvature, for pressure from 0 barg to site hydrotest pressure.

Data shall be detailed as per datasheet provided in Appendix 1.

This capacity shall also consider specific failure modes that are involved under internal pressure, tensile, bending, collapse loads or any combination of these, in the body and at flange area:

- Reinforcement layer rupture, creeping (in case of non-metallic material),
- Elastomer shearing, delamination, rupture,
- Bonded Flexible Pipe collapse,
- Other.

For any failure mode identified, the reference criteria and the relevant safety factor considered shall be clearly detailed and justified, when not addressed by [API SPEC 17K](#).

Bonded Flexible Pipe shall be designed, manufactured and qualified to ensure that no water ingress (leak path, osmosis, crack, or any other source) can penetrate the internal hose structure.

Bonded Flexible Pipe capacity shall be validated by FE modelling and full scale testing as per sections 9 and 10.

7.1.3 Bonded Flexible Pipe modelling

Bonded Flexible Pipe model shall be detailed with, as a minimum, the following mechanical properties:

- Dimensions
- Weight along the Bonded Flexible Pipe from flange to flange
- Axial stiffness (i.e. elongation vs. tension) as a function of axial force, internal pressure and water depth (i.e. differential pressure)
- Bending stiffness along the Bonded Flexible Pipe as a function of internal pressure and water depth (i.e. differential pressure). It shall be demonstrated that the sampling of the bending stiffness is suitable for the hydrodynamic analyses.
- Torsional stiffness.

Data shall be detailed as per datasheet provided in Appendix 1.

Bonded Flexible Pipe mechanical properties shall be validated by FE modelling and full scale testing as per sections 9 and 10.

7.1.4 Materials

All materials shall be qualified as per [API SPEC 17K](#) requirements.

7.1.4.1 Elastomers

Elastomer materials shall be qualified for use with aromatic content specified for the project, at design temperature, for the design life. It shall be demonstrated that the fluid mixture used for qualifications is representative of the export oil, in particular with respect to aromatic content.

It shall be demonstrated by testing that the elastomer will not be subject to blisters formation under design conditions.

Elastomer strain, shearing and delamination shall be evaluated under design load conditions for installation and operation and demonstrated to be acceptable with respect to relevant safety factor and testing data.

7.1.4.2 Reinforcement layers

In case of non metallic reinforcement material used, the creeping effect shall be considered in the design:

- The structural capacity shall be considered as the minimum guaranteed material strength subject to a constant load over the design life.
- The reinforcement material shall work in the reversible elastic domain under design load conditions.

7.1.5 End Fitting Design

End fittings and flange connections are considered as critical elements of a bonded flexible line and the robustness of their design shall be demonstrated (conservative methodology, high safety factors shall be considered).

The flange end fitting design shall ensure

- A reliable termination and anchoring of all flexible layers
- A leak-tight connection between 2 consecutive flexible elements
- A full transfer of internal and external loads.

The Bonded Flexible Pipe shall be adequately reinforced and stiffened at each flange area to avoid concentrated loads.

7.1.5.1 Termination and anchoring of flexible layers

The flange (termination) area shall be more resistant than the body (main structure), i.e. in case of rupture under any load combination (pressure, tension, bending, fatigue ...), rupture shall not occur in the flange area.

7.1.5.2 Flange connection

The flange design shall be subject to Company approval and, as a minimum, meet the following requirements:

- Either equipped with fully integrated internal and external gasket, by continuity of the inner liner and the outer elastomer layer, or with a double sealing arrangement
- Face to face, metal to metal contact for tightening and load transfer.

Qualification dossier and demonstration of the reliability of the flange design shall be provided to Company for approval.

Flange connection shall be designed against any combination of internal pressure, external pressure, tension (including end-cap effect), bending, torsion loads and fatigue.

7.1.5.3 Bolting

Refer to section 7.4.1.4 for required bolts material, yield strength and hardness, and corrosion protection.

Flange bolting shall be performed by hydraulic powered equipment.

Flange bolting pretension shall be designed with a minimum safety factor 2.0 against the highest extreme dynamic load acting on the flange, including, as a minimum, the effects of:

- Pretension accuracy (effect of friction during bolting sequence, pressurization and control accuracy, etc.)
- Bolts creeping over the design life (incl. coating ageing)
- Rubber creeping in the end-fitting arrangement (if applicable)
- Temperature variations (incl. assembly, installation and operating phases).

This calculation shall be validated by material testing, bolting procedure qualification and Bonded Flexible Pipe qualification testing (see section 10.7).

7.1.6 Collars for buoyancy modules

Bonded Flexible Pipe to be equipped with buoyancy modules shall be manufactured with bonded rubber collars on which the buoyancy modules will be clamped. The collar shall be designed to sustain the maximum buoyancy load with a minimum safety factor of 2.0.

7.2 End connection at surface facility

Extreme and fatigue combined tension / bending loads shall be reduced to a level which respects stress utilisation factors defined in section 7.1.2.

In particular, the bonded flexible line shall be connected to surface facility via:

- Either a decoupling device (to decouple tension and bending loads)
- Or an on-purpose designed integrated bend stiffener.