



Exploration & Production

GENERAL SPECIFICATION

PIPELINES - RISERS

GS EP PLR 109

Design, fabrication and testing of submarine unbonded flexible pipes and risers

07	10/2009	General review
06	10/2008	General review
05	10/2007	General review
04	10/2006	General review
03	10/2005	General review and addition of "EP" root to GS identification
02	10/2004	General review
01	10/2003	General review - Change of Group name and logo
00	10/2002	First Issue
Rev.	Date	Notes

Contents

1. Scope	3
2. Reference documents.....	3
3. Definitions and abbreviations	4
3.1 Definitions	4
3.2 Abbreviations	4
4. Applicability and limitations.....	5
5. Design Brief and Deliverables.....	6
6. Design data.....	6
7. Design Methodology	6
7.1 Pipe structure design	6
7.2 End Fittings Design.....	9
7.3 Loads	9
7.4 In-Place Behaviour	9
8. Design Tools.....	11
9. Qualification program	11
10. Certification of the design by a Third Party	12
11. Manufacturing and testing	12
11.1 Quality Assurance Requirements	12
11.2 Manufacturing Process Requirements.....	15
11.3 Factory Acceptance Tests (FAT)	17
11.4 Delivery.....	17
12. Integrity Management	18
12.1 Risk Assessment	18
12.2 Flexible pipe operating manual	18
12.3 Continuous collection of Operational data	19
12.4 Monitoring systems and testing requirements	20
Appendix 1 Data to be specified in COMPANY Project Specification.....	23
Appendix 2 Operating Manual to be provided, for each flexible pipe.....	24

1. Scope

This General Specification is applicable to the design, procurement, manufacturing and testing of 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. 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.

In case of conflict with listed data, [GS EP PLR 109](#) shall apply.

Standards

Reference	Title
API SPEC 17J	Specification for unbonded flexible pipe
ISO 13628-2	Petroleum and natural gas industries - Design and operation of subsea production systems - Part 2: Flexible pipe systems for subsea and marine applications
ISO 9001 or ISO/TS 29001	Petroleum, petrochemical and natural gas industries - Sector-specific quality management systems - Requirements for product and service supply organizations

The [API SPEC 17J](#) shall be considered as the Prime Reference for the design and construction of the flexible riser.

Professional Documents

Reference	Title
API RP 2RD	Design of risers for floating production systems (FPSs) and tension leg platforms (TLPs)
API RP 17B	Recommended practice for flexible pipe
API Technical Report 17TR1	Evaluation Standard for Internal Pressure Sheath Polymers for High Temperature Flexible Pipes
API Technical Report 17TR2	The Ageing of PA-11 in Flexible Pipes
DNV-RP-F206	Riser Integrity Management

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS EP EXP 311	Plant integrity. Minimum inspection requirements
GS EP PLR 001	Documentation requirements
GS EP PLR 002	Organisation of the design works
GS EP PLR 100	Submarine pipeline systems
GS EP PLR 401	Installation of submarine pipelines
GS EP PVV 611	Welding of pressure containing piping and equipment
GS EP SAF 337	Passive fire protection: Basis of design

3. Definitions and abbreviations

3.1 Definitions

Throughout this specification, the following definitions apply:

- **Annulus** The space between the internal pressure sheath and the outer sheath.
- **Bore** The Internal flexible pipe volume delimited by the pressure sheath.

3.2 Abbreviations

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

- **FMECA** Failure Mode Effects and Criticality Analysis
- **BSF** Bend Stiffener
- **NCR** Non Conformance Request
- **COC** Certificate of Conformance
- **PFP** Passive Fire Protection
- **FAT** Factory Acceptance Test
- **PPS** Project Specification

- **IRC** Independent Review Certificate
- **PT** Test Pressure to be applied during the FAT
- **MBR** Minimum Bending Radius
- **UV** Ultra Violet Radiation
- **MQP** Manufacturing Quality Plan
- **VIV** Vortex Induced Vibration
- **NCR** Non Conformance Request
- **PFP** Passive Fire Protection
- **PPS** Project Specification
- **PT** Test Pressure to be applied during the FAT
- **UV** Ultra Violet Radiation
- **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 unbonded flexible pipelines and risers.

Applicability:

This specification applies to unbonded flexible pipe and does not cover bonded flexible pipe, kill and choke pipeline, flexible pipe with non-metallic tensile armour wires and umbilical.

This specification addresses both static (buried and unburied) and dynamic (riser and jumper) applications of flexible pipe.

This specification covers the use of flexible pipe for the transportation of crude oil, stabilised or commercial oil, rough or treated gas, injected or treated water, methanol and glycol.

This specification does not apply to the transportation of cryogenic products.

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 riser configuration
- Procuring materials, manufacturing, assembling, inspecting, testing and storing all flexible pipes and associated equipment
- Verifying that all goods and services to be delivered meet the specified requirements, and providing adequate documentation.

Basic Principle:

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

5. Design Brief and Deliverables

The type and details of a flexible pipe structure and configuration shall be selected according to:

- The fluid composition
- The type of application: static (buried or unburied), dynamic riser or jumper
- The design and operating conditions
- The external environment conditions such as met-ocean data, geometrical limitation, and attachment point displacement, etc.

The reasons for the selection of the flexible pipe structure and of each individual layer characteristics shall be fully justified and documented.

Limitation and risk associated to each layer shall be identified and quantified. Measures taken to alleviate these risks shall be described in details.

Similarly, the design of the end fitting shall be documented in details. End fittings detailed drawings shall be disclosed.

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

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

6. Design data

The information required to design a flexible pipe is defined in the [GS EP PLR 100](#) and the [API SPEC 17J](#).

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

Although it is understood that the design of flexible pipe involves an iterative process combining the selection of material type, grade and thickness for each layer and the definition of the configuration (static behaviour, dynamic riser: free-hanging, lazy-wave, etc.) it has been decided to separate the two issues for clarity purposes.

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 Pipe structure design

Based on the type of fluid transported, a smooth bore or a rough bore structure could be selected. Each flexible pipe layer shall be designed so as to comply with the Prime References requirements.

7.1.1 Polymer sheaths

This section applies to all the non metallic layers manufactured as a sheath i.e. internal tube, pressure sheath, anti-collapse sheath, outer sheath and any intermediate sheath.

Qualification and design of the polymer layer shall have been performed according to requirement specified on [API Technical Report 17TR1](#) and [API Technical Report 17TR2](#).

For smooth bore structures in subsea application, the use of anti-collapse polymer sheath is mandatory.

For all polymer sheaths, minimum allowable thickness shall be documented, and it shall be clearly specified whether it is driven by manufacturing constraints and/or design requirements.

For hydrocarbon line, the pressure sheath material shall be selected so as to allow visual identification of flaws i.e. it shall not be black.

To complement the Prime References requirements the following issues and their variations along the field life shall be addressed and fully documented in order to justify the polymer sheaths material and thickness selected:

- Compatibility with the transported fluid and operating condition (fluid chemical additives and media used for hydraulic testing shall be analysed too), mechanical creep and degradation of the polymer sheath by the inner fluid and environment.
- Permeability to the different components of the transported fluids shall be determined for the range of temperatures representing the design conditions. Effect of degradation shall be analysed. The permeation results shall enable the corrosion rate of steel armours and H₂S resistance to be calculated.
- Wear induced by external ancillaries equipment shall be accounted for in the design of the outer sheath.
- In the case of a multi-layer PVDF system, diffused gas and entrapped gas in between the layers shall be evaluated and subsequent potential for collapse shall be prevented. Maximum allowable decompression rate shall be provided.
- Where applicable, potential creeping of polymer sheath due to external hydrostatic pressure and/or mechanical contact pressure shall be evaluated and documented (for instance outer sheath creeping into insulation layers, anti collapse sheath creeping into pressure vault).

7.1.2 Metallic layers

This section applies to carcass, pressure armour and tensile armour wires and outlines additional requirements to complement the Prime References' ones.

For each flexible pipe structure stresses in the pressure vault and tensile armour wires shall be provided and compared to the usage factor defined in the [API SPEC 17J](#).

For dynamic application, only product family I and III according to [API RP 17B](#) are allowed. Product family II may be allowed for dynamic oil offloading lines.

Residual stress in steel wire and welds induced during the manufacturing of the layer shall be determined and accounted for in the design.

Selection of steel wires and SSC/HIC testing

For all service applications, selection of steel wires grade (sour or sweet) and dimension shall be based on SSC and HIC testing results covering the predicted worst environmental conditions present in the pipe annulus during operation as required in the Prime References. These conditions are defined as:

- Flooded annulus with synthetic seawater saturated in corrosion products
- H₂S and CO₂ partial pressures determined by diffusion calculations through the polymer sheath of H₂S and CO₂ contents in the bore at normal operating pressure (not considering peak effects).

Detailed documentation shall be provided.

SN Curve selection

For dynamic applications, S-N data generated as per the Prime References requirements shall be documented in details.

For each steel material used in the structure, SN curve shall be presented.

The SN curves to be employed in the design shall be established with a 2.3% failure probability

The effect of the annulus environment due to permeation in normal operating condition shall be accounted for, including water condensation.

SN curves shall be based on experimental data covering the range mean and alternate stress of the application.

Standard mean stress correction, Goodman or Gerber is valid for dry environment condition. However for corrosion fatigue, mean stress correction methodology shall be presented and submitted to COMPANY approval.

Endurance limit is not acceptable unless it has been validated by experimental data.

This must be documented and submitted to COMPANY for approval.

7.1.3 Polymer tapes

For polymer tape selection consideration shall be given to the maximum operating temperature and maximum contact pressure

7.1.4 Insulation tapes

The detailed design of insulated flexible pipe shall account for insulation material thermal properties based on a flooded annulus case.

Loss of thermal characteristics induced by ageing, water absorption, compression of material (caterpillar, hydrostatic pressure) shall be addressed. The combined effect of temperature shall be captured in all cases. The design shall be based on detailed testing results covering the conditions associated with the project development under consideration. These tests results shall be provided to the COMPANY for review. When these tests results are not available, dedicated testing for the project development under consideration shall be conducted.

7.1.5 High Strength tapes

The same requirements as per 7.1.3 above apply.

In addition, ageing of these tapes under the annulus environment shall be addressed.

Abrasive wear of these tapes shall be addressed.

7.2 End Fittings Design

In addition to the Prime References requirements the following issues and their variations along the field life shall be addressed and fully documented:

- Critical location in terms of stress shall be identified
- At those locations stresses and resulting usage factor shall be presented for all load cases
- The polymer sheaths shall be continuously supported by a steel support
- Stress concentration factors at and within the end fitting shall be established and documented
- Inconel 625 clad shall be provided for the end fittings (bore, groove and flange face). The weld overlay procedure and qualification shall be compliant with the requirements included in the COMPANY General Specification **GS EP PVV 611**.

The design shall allow and account for support loads from any ancillary components attached to the end fitting, including bend stiffeners, restrictors accessories used for pipe installation and topside piping loads.

When the flexible pipes are insulated, a dedicated system for the insulation of the end fitting may be required to prevent thermal losses at these locations. In all cases, the thermal performance of the system at the end fitting location shall be at least identical to the performance of the flexible line current section. Long term performance of such system shall be demonstrated and effect of installation addressed.

For dynamic riser application, only one intermediate connection located in the vertical part of the riser is allowed. In that case the annulus of the bottom section shall be linked to the annulus of the top section through the intermediate connection.

The use of multiple sections for offloading lines is not acceptable.

7.3 Loads

In order to address the requirements from the two previous sections, all analyses and structure definition shall take into account the loads encountered during the whole cycle life of the flexible pipe.

Loads cases shall be combined with manufacturing tolerances of the steel and plastic layers.

7.4 In-Place Behaviour

The additional requirements to the Prime References presented below shall be addressed.

7.4.1 Collapse resistance

The flexible pipe design shall satisfy the collapse resistance criteria when the flexible pipe is empty and bent to its MBR.

The effect of carcass erosion, pressure vault corrosion and cross section ovality shall be accounted for.